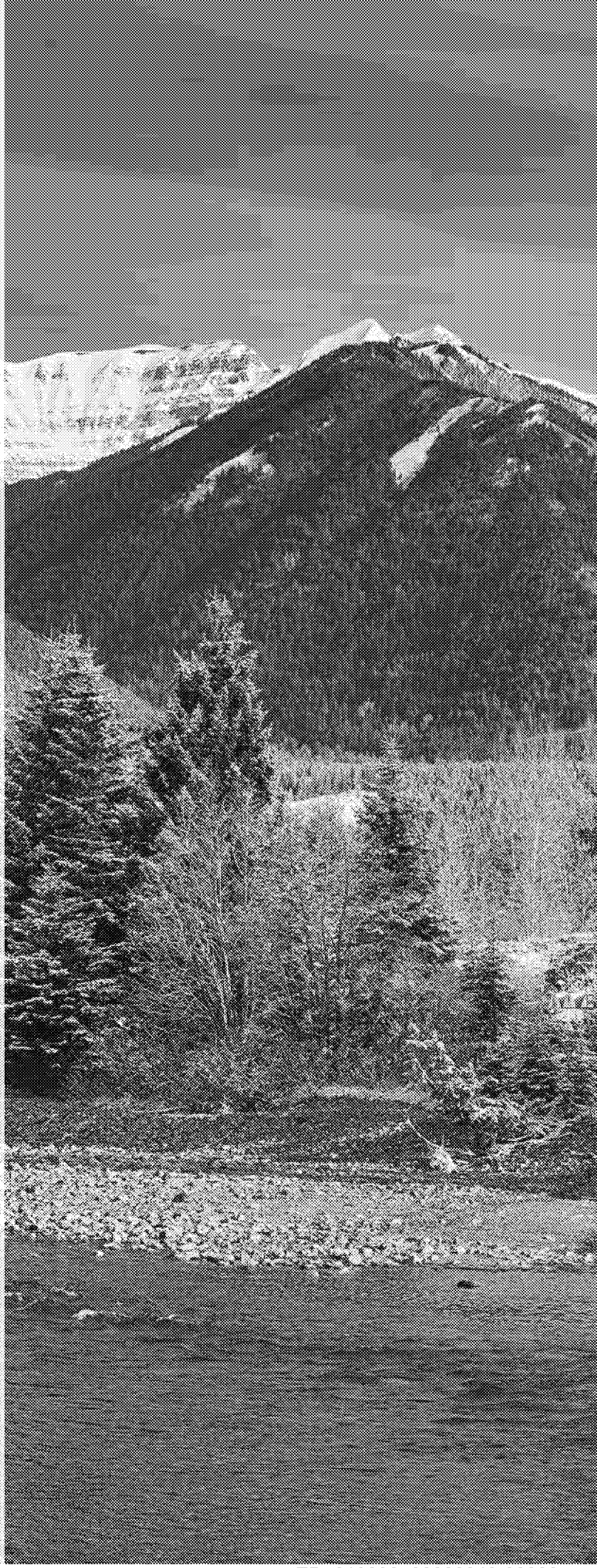
PERMIT 107517

ENVIRONMENTAL MONITORING COMMITTEE

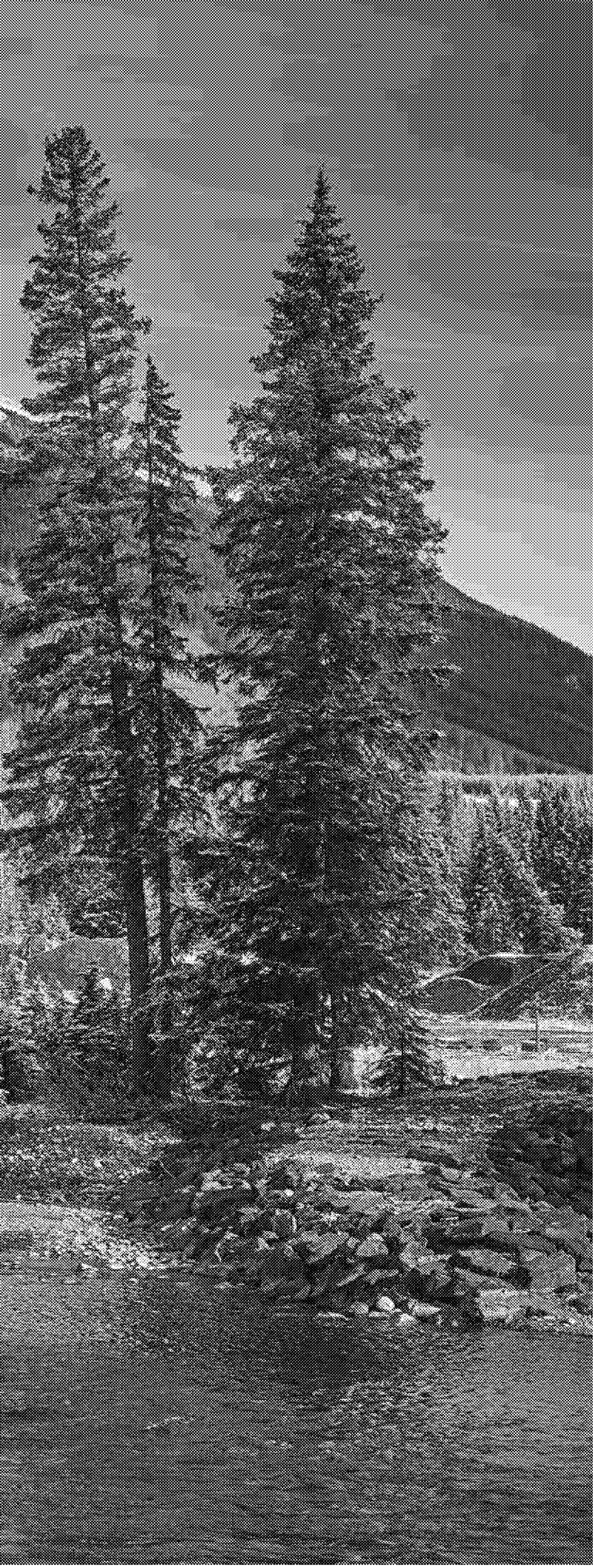
2019 Public Report



About this Report

This report is prepared by the members of the Environmental Monitoring Committee, and produced and distributed with the support of Teck. For information about the Environmental Committee and what it does, please see page 9.

This report summarizes the 2018 results presented in the technical reports that Teck submitted to the Ministry of Environment and Climate Change Strategy. These technical reports are available to the public and you can find them at https://www.teck.com/responsibility/sustainability-topics/water/water-quality-in-the-elk-valley/research-and-monitoring-reports/



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Message from the Environmental Monitoring Committee

Dear readers,

This is our fifth annual summary of the environmental reports we have reviewed. You can find our previous reports at www.teck.com/ElkValley.

Teck's environmental monitoring programs in the Elk Valley produce a lot of complex information. We've done our best to highlight what we feel are the important findings in Teck's results and analyses from 2018. The technical reports that form the basis of our summary are available to the public, and you can access them if you wish. We've provided a list of these reports, and directions on where to find them, at the end of this report.

This was another busy and productive year for our committee. We met five times in person for a week each time and had 15 conference calls. We reviewed 65 reports, study designs, and data packages, and provided 1,442 pieces of technical advice to Teck and the Director, Regional Operations Branch, Ministry of Environment and Climate Change Strategy. We are proud to be members of this committee and we are committed to providing scientific recommendations to improve, broaden, and support environmental monitoring in the Elk Valley.

In conjunction with the release of this report, we hold an annual public meeting. This meeting is intended to give you an opportunity to ask us questions about the information we have reviewed.

We hope that you are able to find and understand information about water quality in the Elk Valley that is important to you. We want to keep improving how we share this information, so please let us know what we can do better. You can chat with us directly at the public meeting, fill out our feedback form, or email us anytime through our facilitator, Lynne Betts at emcpermit107517@gmail.com.

Sincerely,

Patrick Williston
on behalf of the British Columbia Ministry of Environment and Climate Change Strategy

Heather McMahon
on behalf of the Ktunaxa Nation Council

Alison Neufeld
on behalf of the British Columbia Ministry of Environment and Climate Change Strategy

Jesse Sinclair
on behalf of the Ktunaxa Nation Council

Bruce Kilgour
Independent Aquatic Scientist

Carla Fraser
on behalf of Teck

Jennifer Jacobsen
on behalf of the Interior Health Authority

Mark Digel
on behalf of Teck

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How Teck Manages Water Quality in the Elk Valley

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The Elk Valley Water Quality Plan

Extracting coal from underground layers, or seams, causes certain substances to be released into nearby creeks and streams that then flow into rivers and lakes. Monitoring results indicate that the concentrations of these substances are increasing in areas impacted by mining in the Elk Valley.

In April 2013, the British Columbia Minister of Environment issued Ministerial Order No. M113 that required Teck to develop an area-based management plan and to identify the actions it will take to manage water quality downstream of its five steelmaking coal mines. The mine-related substances of concern in that order are selenium, nitrate, sulphate, cadmium, and calcite.

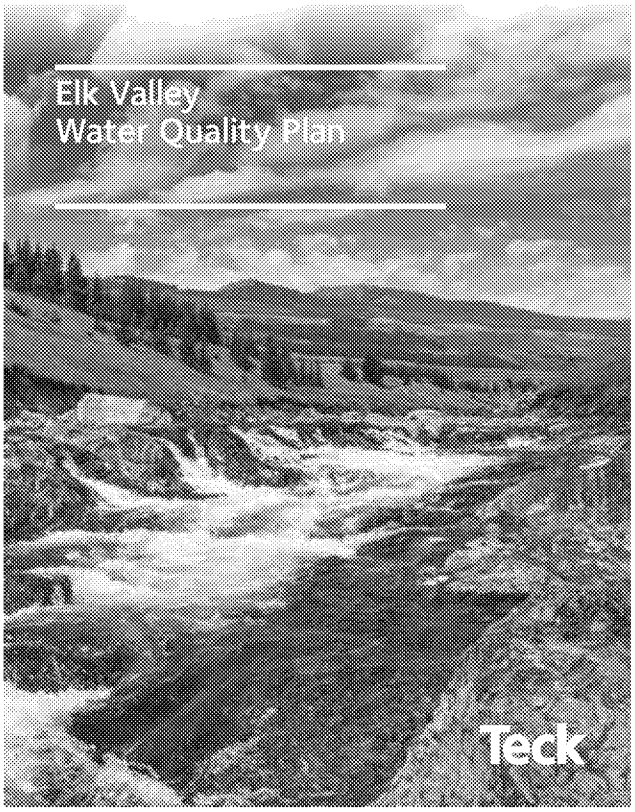
Between 2013 and 2014 Teck developed the Elk Valley Water Quality Plan with feedback from the public, First Nations, provincial and federal governments, technical experts, and other stakeholders. Teck submitted the Elk Valley Water Quality Plan to the Minister in July 2014 and it was approved in November that same year. The Elk Valley Water Quality Plan guides water quality management in the Elk Valley and has these four environmental objectives:

- protect aquatic ecosystem health
- manage bioaccumulation of mine-related substances in the environment
- protect human health
- protect groundwater

The Elk Valley Water Quality Plan, or EVWQP, has targets (limits) for the concentration of selenium, sulphate, nitrate, and cadmium in surface water at seven specific locations—called order stations[1]—in the Elk Valley and in the Koocanusa Reservoir. The EVWQP also has targets for the amount of calcite in streams influenced by mining. These water quality targets—both short-term (2014 to 2019), medium-term (2020 to 2025), and long-term—are meant to first stabilize and then decrease concentrations over time to protect the most sensitive aquatic life and human health from mining-related effects on water quality.

You can learn more about the Elk Valley Water Quality Plan here:

https://www.teck.com/media/2015-Water-elk valley_water_quality_plan_T3.2.3.2.pdf



[1]These seven locations were specified in Ministerial Order No. 113, which is why they are referred to as "order stations".

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The Elk Valley Permit

Following the approval of the Elk Valley Water Quality Plan, the Ministry of Environment issued Permit 107517—often called the Elk Valley Permit. Many of the actions and commitments described in the Elk Valley Water Quality Plan were made legal requirements by this permit, including the target concentrations for water quality. Teck must meet all the requirements in this permit.

Permit 107517 does not replace any of the permits previously issued to each of the mine operations. It is regionally focused and adds another layer of legal requirements for Teck.

You can can find more information about Permit 107517 on the BC government website:

https://www2.gov.bc.ca/gov/content/environment/waste-management/waste-discharge-authorization/search-status-and-documents

Water Quality Targets

Water quality targets are limits for the amount of selenium, sulphate, nitrate, and cadmium in the water. These targets are meant to protect aquatic life based on available data during the development of the Elk Valley Water Quality Plan. There are two types of water quality targets in Permit 107517: compliance limits and site performance objectives. We refer to both of these as permit limits in this report.

Compliance limits are set for compliance points. Compliance points are water monitoring stations that are downstream from each of Teck's mine operations in the Elk Valley. These points correspond to stream locations where all or most of the mine-influenced water accumulates from an operation. There are eight compliance points.

Site performance objectives are set for order stations. Order stations are water monitoring stations that are further downstream from Teck's mining operations where water that is mine-influenced is mixed with water that is not. Because of this mixing, concentrations at order stations are expected to be lower than at compliance points. There are seven order stations.

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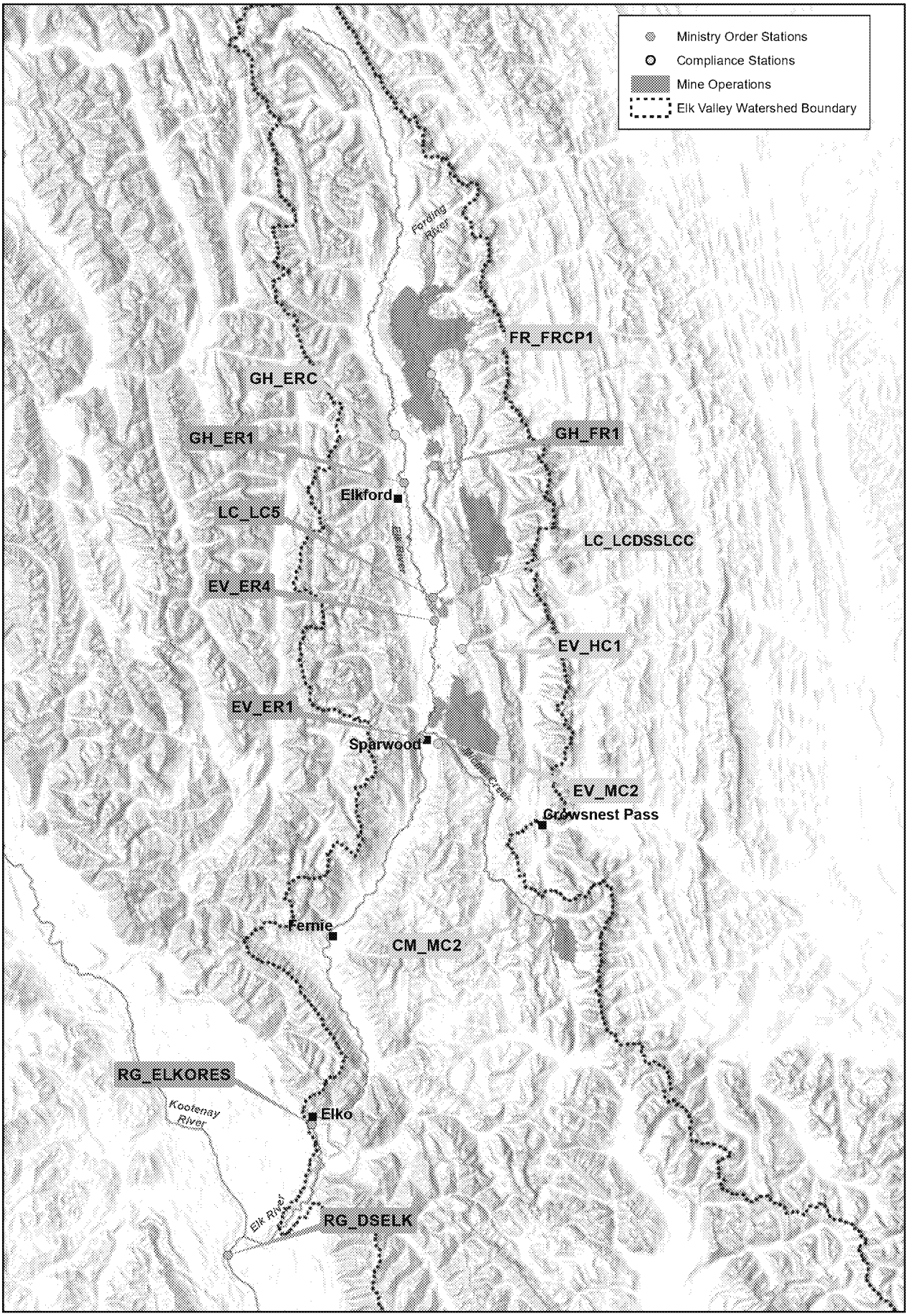

Figure 1. Compliance points, order stations, and boundaries of Permit 107517 in the Elk Valley.

The Environmental Monitoring Committee

Permit 107517 requires Teck to form an Environmental Monitoring Committee (EMC). In 2018, the members of this committee included:

- an independent aquatic scientist
- two representatives from the British Columbia Ministry of Environment and Climate Change Strategy (ENV)
- one representative from the British Columbia Ministry of Energy, Mines, and Petroleum Resources (EMPR)
- one representative from the Interior Health Authority (IHA)
- two representatives from the Ktunaxa Nation Council (KNC)
- two representatives from Teck

The federal government (Environment and Climate Change Canada) has been invited to participate on the committee, but has declined active participation. Federal representatives have, however, agreed to consider requests from the EMC to provide specific input on a case-by-case basis.

Permit 107517 also states that the Environmental Monitoring Committee must review these monitoring and management programs:

Monitoring Programs

- Surface Water Monitoring
- Groundwater Monitoring
- Calcite Monitoring
- Local Aquatic Effects Monitoring
- Regional Aquatic Effects Monitoring
- Toxicity Testing
- Human Health Risk Assessment

Management Programs

- Adaptive Management
- Tributary Management

All of these programs are required under Permit 107517 and are focused on the Elk River watershed and the Canadian portion of the Koocanusa Reservoir. The Environmental Monitoring Committee reviews all the information associated with these programs and provides advice to Teck. It is up to Teck to respond to or adopt the committee's advice. These programs are strengthened by the advice the committee provides.

The Environmental Monitoring Committee cannot approve Teck's programs. And it does not replace or affect the consultation process between the BC provincial government and First Nations.

The members on the Environmental Monitoring Committee have different areas of expertise and bring different perspectives to the committee's discussions about Teck's monitoring and management programs. The committee provides technical advice and the KNC representatives also provide advice relating to the Ktunaxa's stewardship principles and worldview.

Ktunaxa Stewardship

Archaeological evidence indicates that for more than 10,000 years the Ktunaxa (pronounced 'k-too-nah-ha') people have occupied the lands along the Kootenay and Columbia Rivers, and the Arrow Lakes of British Columbia. The Ktunaxa Territory is divided into Land Districts, and the Elk Valley falls within one of these districts, called Qukin ?amak?is, or Raven's Land. The Ktunaxa people have continuously used and occupied the Elk Valley area within Qukin ?amak?is, and the formation of the geography of the Elk Valley is described in the final events of the Ktunaxa Creation story.

Because of the Ktunaxa's deep connection to the Elk Valley, the Ktunaxa Nation Council (KNC) has been invited to have three representatives on the EMC to provide both science-based advice and advice relating to the Ktunaxa's stewardship principles and worldview.

Information about the Ktunaxa Nation, the Ktunaxa creation story, and Ktunaxa law has been provided by KNC and can be found in Appendix A.

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Projecting Future Water Quality

To examine and understand how activities at its five coal mines affect water quality, Teck has developed a regional water quality model. This model simulates how historical, current, and future mining activities affect the concentrations of selenium, sulphate, nitrate, and cadmium in the Elk Valley and the Koocanusa Reservoir. It also simulates how the various mitigation measures Teck has planned (water treatment and clean-water diversions for example) will affect water quality. The model uses historical and current information to project future concentrations.

Teck developed the first regional water quality model in 2014 to inform the EVWQP. Teck is required to update the model every three years, and the first update was submitted to the Director in October 2017. The water quality projections mentioned later in this report are taken from the 2017 model. Work on the next update is underway and is due to the Director in October 2020.

The EMC does not provide advice on the water quality model or its development, but it does review the model's outputs. This information is helpful to the EMC when members are reviewing and providing advice on Teck's monitoring and management programs.

The initial implementation plan in the EVWQP was based on the 2014 regional water quality model. The updated projections and schedules for active water treatment in the 2017 model required Teck to subsequently update the EVWQP implementation plan. Teck has now finalized the 2019 Implementation Plan Adjustment and it can be found at https://www.teck.com/responsibility/sustainability-topics/water/water-quality-in-the-elk-valley/news-and-publications/.

Who is the Director?

The Director is the representative from the regional government office within the British Columbia Ministry of Environment and Climate Change Strategy that is responsible for issuing permits under the Environmental Management Act and for determining compliance with permit requirements. All the study designs, plans, and reports required under Permit 107517 are submitted to the Director, many of which require written acceptance or approval.

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Adaptive Management

Adaptive management is an approach to environmental management that helps environmental managers make progress towards environmental goals, while at the same time allowing them to incorporate learnings along the way. Adaptive management combines research with management actions to help managers systematically test assumptions, learn, and adapt.

Teck is required to develop and implement an adaptive management plan. Teck began developing the plan in early 2015 and submitted it to the Director in August 2016. The KNC and Teck requested an extension to make sure the document was acceptable to KNC. Following several rounds of discussions with the EMC, Teck submitted the most recent version of the plan to the Director in December 2018. It was formally accepted by the Director in May 2019.

The adaptive management plan was developed to support the implementation of the EVWQP to achieve water quality and calcite targets; to ensure that human health and the environment are protected (and where necessary, restored); and to facilitate the continuous improvement of water quality in the Elk Valley.

Following the six stage adaptive management cycle (see text box), Teck's adaptive management plan is guided by six management questions that will be evaluated through the implementation of the EVWQP. The six management questions identified in Teck's 2018 Adaptive Management Plan are:

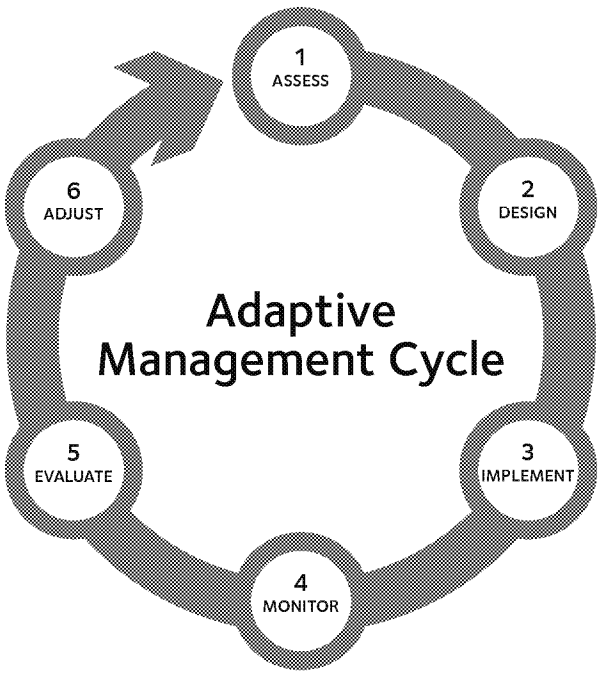
Management Question 1:
Will water quality limits and site performance objectives be met for selenium, nitrate, sulphate, and cadmium?

Management Question 2:
Will the aquatic ecosystem be protected by meeting the long-term site performance objectives?

Management Question 3:
Are the combinations of methods for controlling selenium, nitrate, sulphate, and cadmium included in the implementation plan the most effective for meeting limits and site performance objectives?

What is Adaptive Management?

It is a systematic, rigorous approach to environmental management structured around a six stage management cycle (a form of the plan-do-check-act management loop). It focuses on learning about important uncertainties, while at the same time implementing management actions based on the current understanding. It provides a framework in which management actions are adapted based on what is learned.



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Management Question 4:
Is calcite being managed effectively to meet site performance objectives and protect the aquatic ecosystem?

Management Question 5:
Does monitoring indicate that mine-related changes in aquatic ecosystem conditions are consistent with expectations?

Management Question 6:
Is water quality being managed to be protective of human health?

The 2018 plan also identifies continuous improvement goals for each management question and a response framework for determining when additional mitigation actions or other adjustments may be needed to protect the aquatic ecosystem and human health.

Teck is required to submit an annual report that describes the activities undertaken during the previous year in each stage of the adaptive management cycle. Following the Director's acceptance of Teck's 2018 Adaptive Management Plan, Teck submitted its first annual report in July 2019. In addition to a description of activities undertaken, the annual report summarized the results and learnings from 2018 and described Teck's next steps.

Teck is also required to update its adaptive management plan every three years. The next update is due in December 2021. Teck continues to work with the EMC to develop a means of tracking progress towards continuous improvement goals; to develop and implement additional triggers to the response framework (groundwater and calcite, for example); and to develop definitions of unacceptable conditions for integration in the response framework.

The EMC will continue to review and provide advice on the three-year plan update and the annual reports.

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What We Learned From the Monitoring Programs in 2018

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Surface Water Quality

In addition to the eight compliance points and the seven order stations, Teck routinely monitors water quality at 88 other locations in the Elk Valley. All monitoring results are used to evaluate Teck's compliance with its permit requirements and its progress towards achieving the objectives set in the Elk Valley Water Quality Plan.

For compliance points and order stations:

- results for selenium, nitrate, sulphate, and cadmium are compared to permit limits
- results for other mine-related substances are compared to BC water quality guidelines

For the 88 other monitoring locations:

- results for selenium, nitrate, sulphate, and cadmium are compared to BC water quality guidelines
- results for other mine-related substances are compared to BC water quality guidelines

Monitoring results are presented in an annual report that Teck submits to the Director and the EMC in March every year.[2]

[2]Permit 107517 Annual Water Quality Monitoring Report, 2018 (March 2019)

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Compliance

Permit 107517 has specific targets (limits) for the concentration of selenium, nitrate, sulphate, and cadmium at the compliance points and order stations, and Teck is required to meet these limits to be in compliance. Water quality in the Elk Valley is affected by several factors including background conditions, the placement of waste rock, annual and seasonal rain and snow (and the resulting surface flows, or hydrology), water treatment, and how the operations manage water. Changes to these factors influence whether or not a location is in compliance with the limits set in Permit 107517.

In 2018, Teck maintained compliance at the compliance points and order stations for 88.5% of water samples tested. There were recurring exceedances of permit limits at two compliance points: FRCP1, a site on the upper Fording River; and LCDSSLCC, a site on Line Creek. One order station, DSELK in the Koocanusa Reservoir near the confluence of the Elk River, reported a non-compliance for the average concentration of selenium in the month of April.

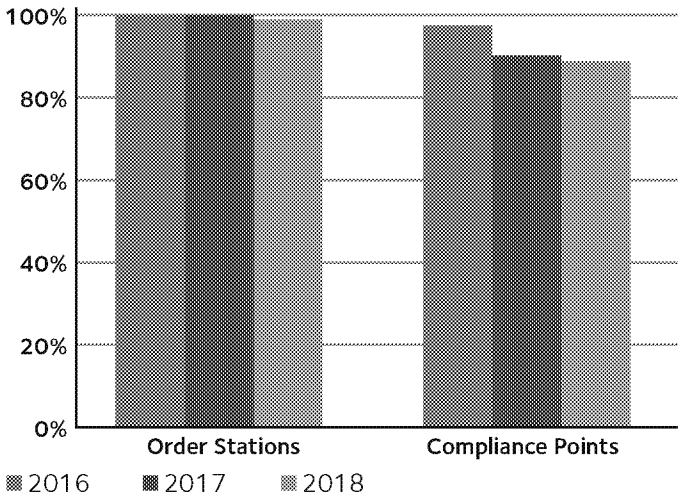

Figure 2. Teck's compliance with permit limits at order stations and compliance points from 2016 to 2018.

Fording River (FRCP1)

The FRCP1 location is a compliance point on the upper Fording River, approximately 525 m downstream of Cataract Creek. It is intended to capture the mixed water of the Fording River and all tributaries (both mine-influenced and not mine-influenced) that flow into it. One of those tributaries, Cataract Creek, is influenced by waste rock at the Fording River Operations. From October to December 2018, mixed water in the Fording River flowed underground leaving only water from Cataract Creek flowing past the compliance point. Water samples collected at this compliance point during this time were representative of Cataract Creek, not mixed waters in the Fording River. Changes in hydrology and undiluted waste rock runoff were important drivers of the selenium, nitrate, and sulphate exceedances at FRCP1 in 2018 (Figures 3 to 5).

Teck has been monitoring the aquatic biota downstream of this location to evaluate whether the biota is being affected by these higher concentrations through the winter months. Teck and the EMC continue to review these results. To reduce the concentrations of mine-related substances in the Fording River, Teck is currently constructing an active water treatment facility just south of the Fording River Operations. The facility start up will commence late 2020 with a ramp up to full operation in 2021. This facility will treat water from Cataract Creek, Swift Creek, and Kilmarnock Creek.

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Selenium, Nitrate, and Sulphate Concentrations at FRCP1 in 2018

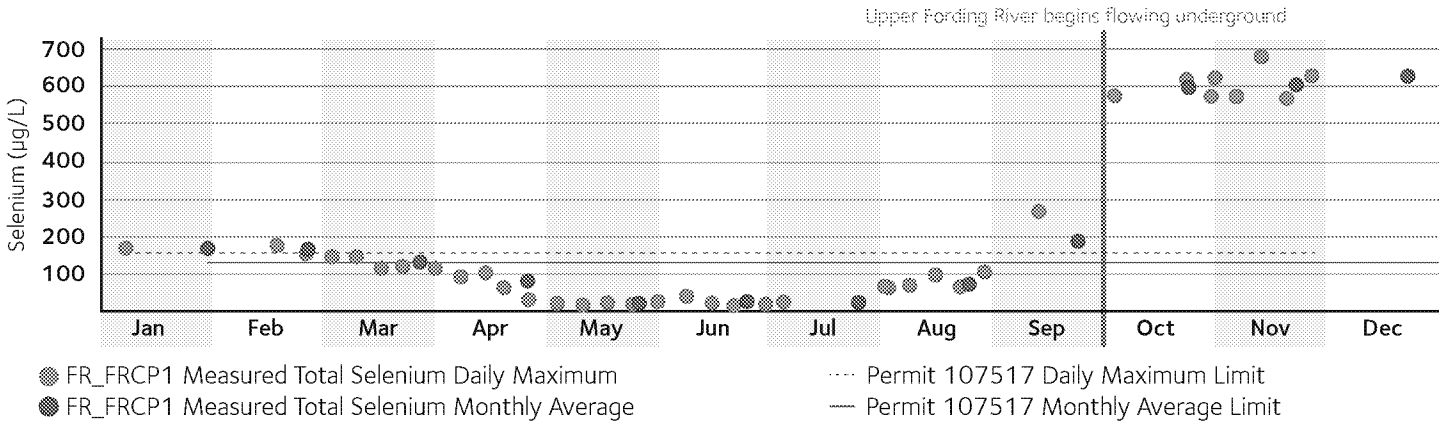

Figure 3. Selenium concentrations (in µg/L) at the Fording River compliance point, 525 m downstream of Cataract Creek, in 2018.

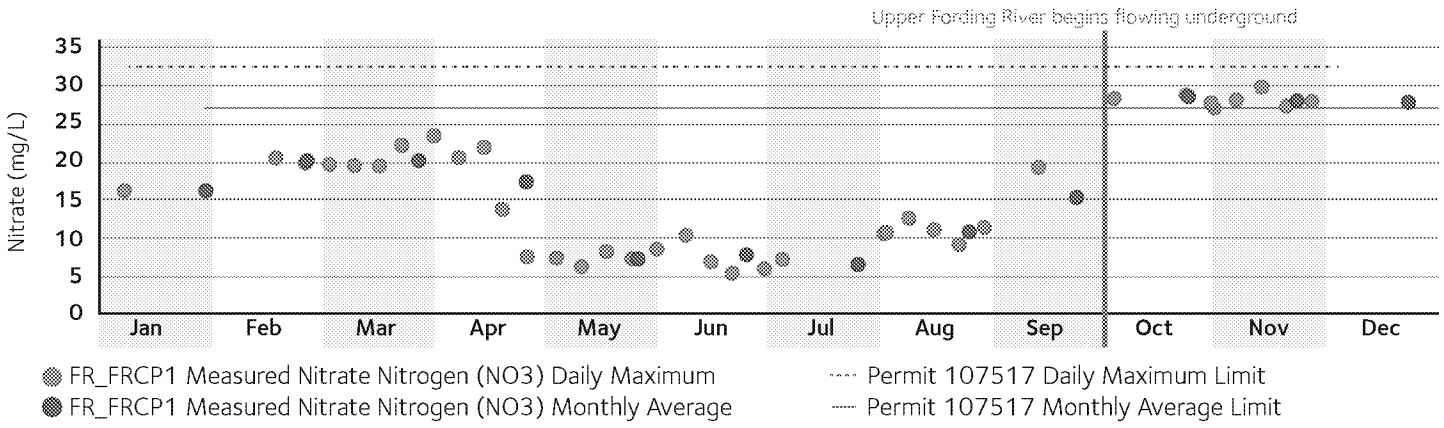

Figure 4. Nitrate concentrations (in mg/L) at the Fording River compliance point, 525 m downstream of Cataract Creek, in 2018.

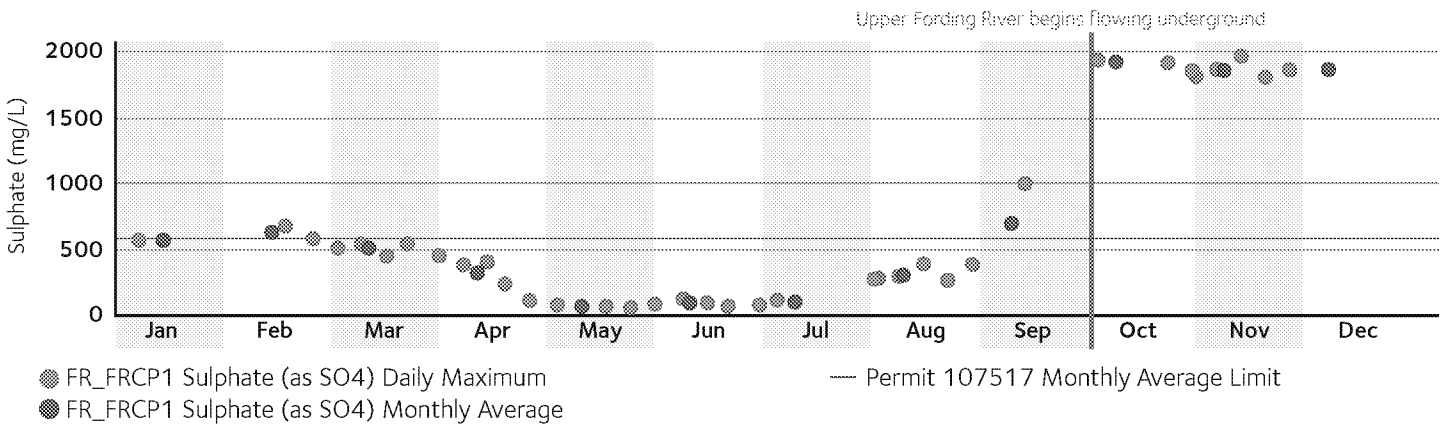

Figure 5. Sulphate concentrations (in mg/L) at the Fording River compliance point, 525 m downstream of Cataract Creek, in 2018.

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Line Creek (LCDSSLCC)

The LCDSSLCC location is a compliance point in Line Creek approximately 1500 m downstream from the West Line Creek Active Water Treatment Facility. In February 2018, the facility was temporarily shut down to add an advanced oxidation process (see page 39 for more information). In the three months that followed, selenium concentrations in Line Creek were above permit limits. The treatment facility was restarted in October 2018 and selenium concentrations at the Line Creek compliance point returned to below permit limits (Figure 6).

Nitrate concentrations also exceeded permit limits at this location in 2018 (Figure 7). The treatment facility removes 90% of the nitrate, but concentrations in Line Creek remained close to, or slightly above the permit limits. Teck continues to monitor and assess the potential effects of these nitrate levels to the aquatic biota in Line Creek. See page 39 for more information on these monitoring results.

Teck's updated modelling projects to meet compliance limits with its nitrate concentrations by 2026 when the active water treatment facility at West Line Creek is expanded.

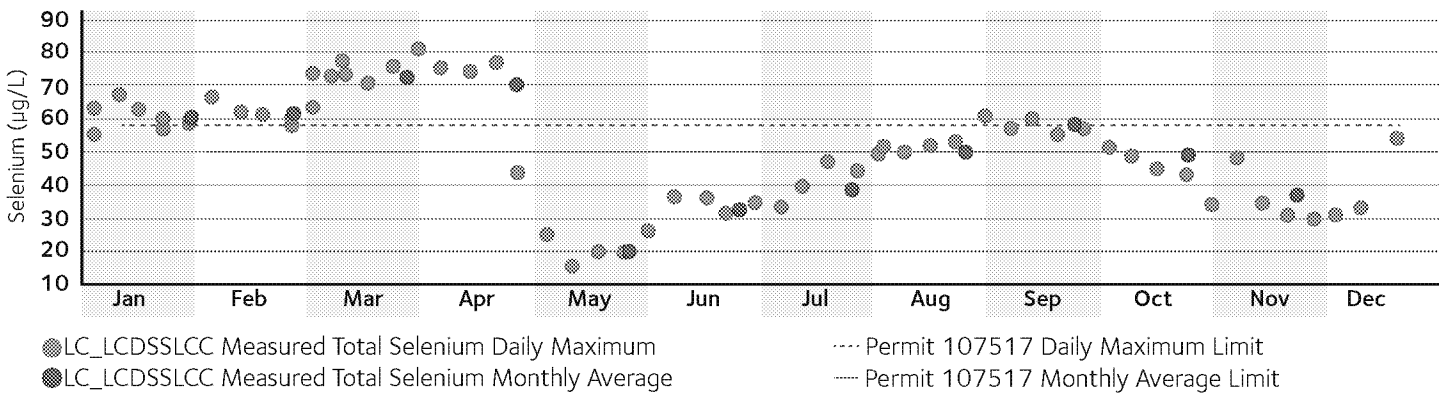

Figure 6. Selenium concentrations (in µg/L) at the Line Creek compliance point in 2018.

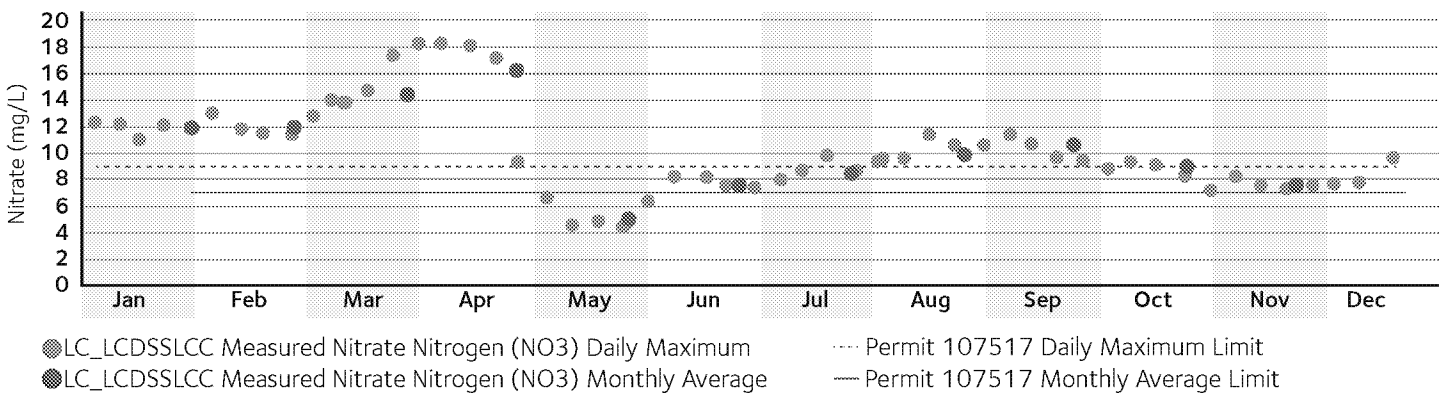

Figure 7. Nitrate concentrations (in mg/L) at the Line Creek compliance point in 2018.

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Koocanusa Reservoir (DSELK)

The DSELK location is an order station in the Koocanusa Reservoir just downstream of the confluence of the Elk River. It is intended to capture the mixed water of the Kootenay River and the Elk River. In April 2018, the reservoir at this location was a river channel running through the bottom of the reservoir. The April water samples were collected from the eastern river bank and the average selenium concentration in April was 2.7 µg/L; the monthly average limit is 2 µg/L (Figure 8).

Upon receiving this result, Teck investigated and found that the riverine condition in April did not allow mixing between the Elk River and the Kootenay River at this location. Teck discovered that the eastern shoreline primarily represented water from the Elk River and the western shoreline represented water from the Kootenay River. See page 43 for more information.

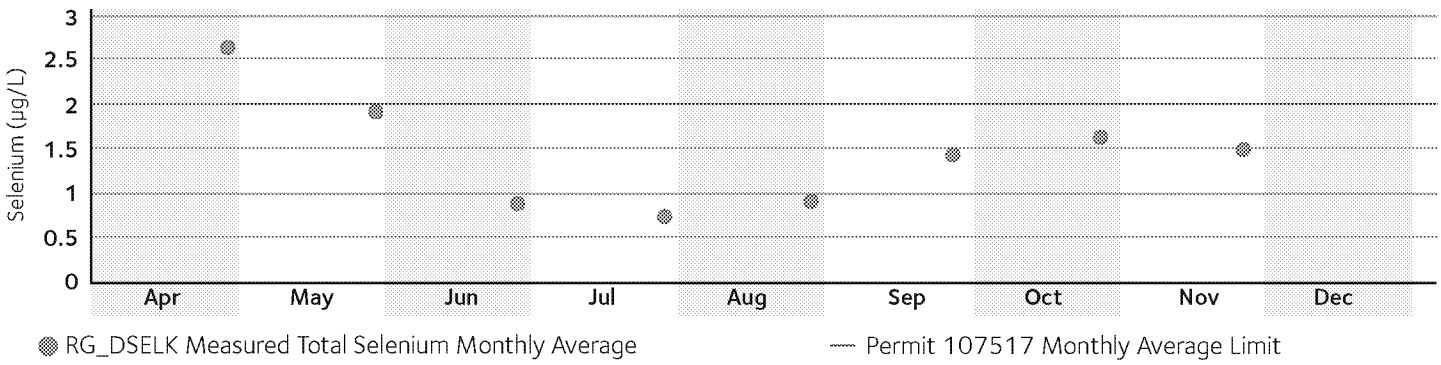

Figure 8. Monthly average selenium concentrations (in µg/L) at the Koocanusa Reservoir order station in 2018.

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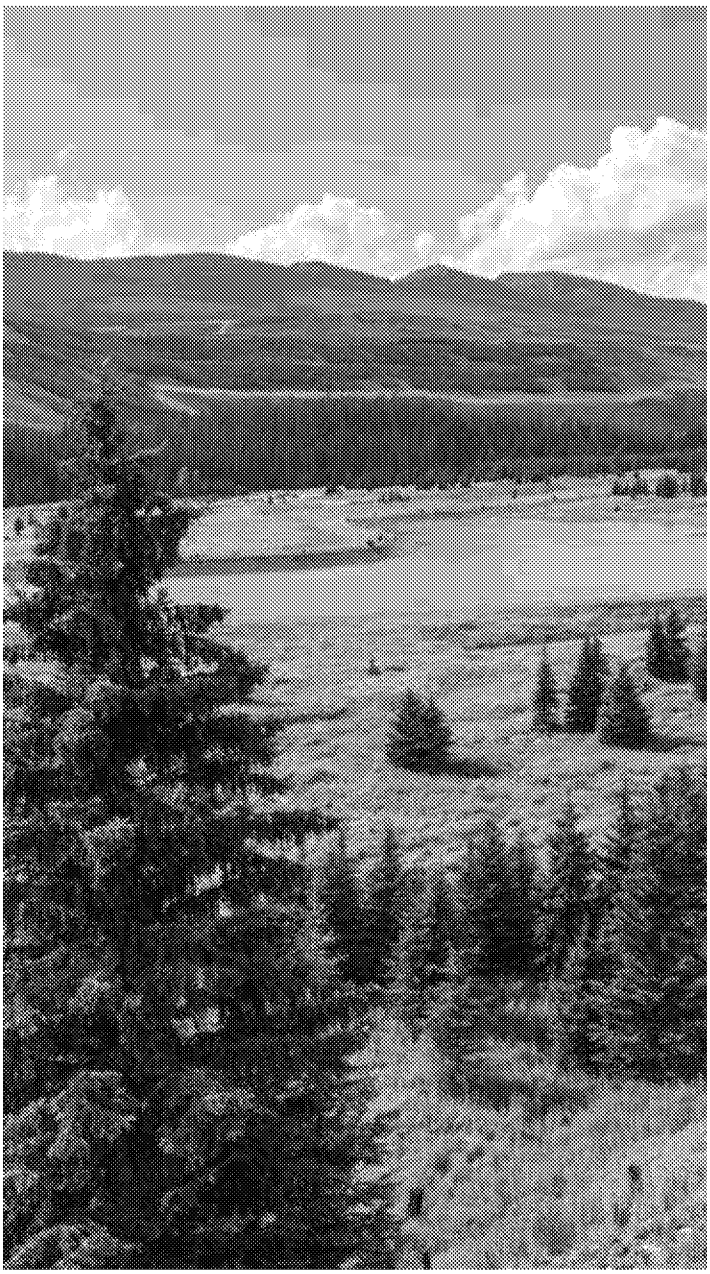
Results Above BC Water Quality Guidelines

BC water quality guidelines are science-based benchmarks intended to protect the most sensitive life stages of the most sensitive aquatic species occurring in the province. These guidelines are policy; they are not enforceable standards. The guidelines are developed by the Ministry of Environment and Climate Change Strategy for consideration in decision making. Results above a BC water quality guideline may or may not result in changes to aquatic biota, depending on site-specific conditions and the sensitivities of the local aquatic biota.



Teck collected approximately 1400 water samples in 2018 and compared the laboratory results to the BC water quality guidelines:

- 24 of 1400 samples taken (1.7%) measured above the aluminum guideline
  - no spatial or temporal patterns
  - has not increased over time
  - not related to mining operations
- 79 of 1400 samples taken (5.6%) measured above the iron guideline
  - occurred at the peak of spring melt
  - no spatial pattern
  - has not increased over time
- 160 of 1400 samples taken (11.4%) measured above the mercury guideline
  - occurred at the peak of spring melt
  - no spatial pattern
  - has not increased over time
  - not related to mining operations
- 51 of 1400 samples taken (3.6%) measured above the cobalt guideline
  - occurred in Corbin Creek and Michel Creek
  - has increased over time
  - related to mining operations
- 15 of 1400 samples taken (1.1%) measured above the nitrite guideline
  - occurred mainly in Corbin Creek (11) and Michel Creek (2)
  - has increased over time
  - related to mining operations
- 66 of 1400 samples taken (4.7%) measured above the uranium guideline
  - occurred mainly in West Line Creek (54) upstream of the active water treatment facility
  - also found in Fording River (9), Corbin Creek (2), and Greenhills Creek (1)
  - related to mining operations

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Trends in Water Quality

Teck continually evaluates its monitoring results to look for trends. Teck then compares those trends to what was projected in the Regional Water Quality Model. If a trend is unexpected, Teck investigates the cause. If the cause is determined to be mining-related, Teck will evaluate options and take appropriate management actions. Teck reports water quality trends in the annual report it submits to the Director and the EMC in March every year.[3] The four mine-related substances identified in the EVWQP—selenium, nitrate, sulphate, cadmium—are the main substances of concern, but nickel and cobalt have recently emerged as additional substances of concern in localized areas.

Selenium

Selenium is a common element found naturally in rock, and it is an essential nutrient for all living things at low concentrations. In water, selenium is taken up by algae and other microorganisms and transferred through the food web where it accumulates in the body tissues of aquatic invertebrates, fish, birds, and other vertebrates—this is called bioaccumulation. When selenium accumulates at high concentrations in the tissues of animals, it can interfere with their reproduction, especially in animals that lay eggs such as fish, birds, amphibians, and reptiles. In humans, long-term exposure to elevated selenium can result in fever, nausea, and selenosis. Selenosis is characterized by multiple organ damage, especially the liver and skin.

Selenium concentrations in the Elk Valley have increased over time and have exceeded permit limits at three locations (see the *Compliance* section on page 15). The Regional Water Quality model projected selenium concentrations would exceed permit limits at certain locations until the commissioning of the Fording River South Active Water Treatment Facility (Figure 9). Teck expects the commissioning of the Elkview Saturated Rockfill Facility (start-up will commence late 2020 with a ramp up to full operation in 2021) will further improve water quality by decreasing selenium (and nitrate) concentrations in Erickson Creek, Michel Creek, and the Elk River.

[3]Permit 107517 Annual Water Quality Monitoring Report, 2018 (March 2019)

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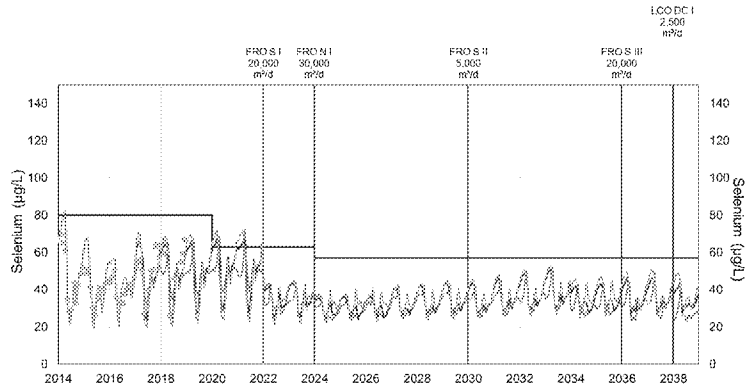
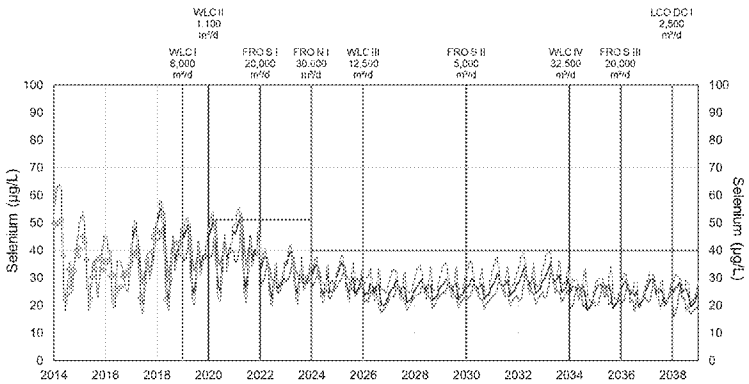
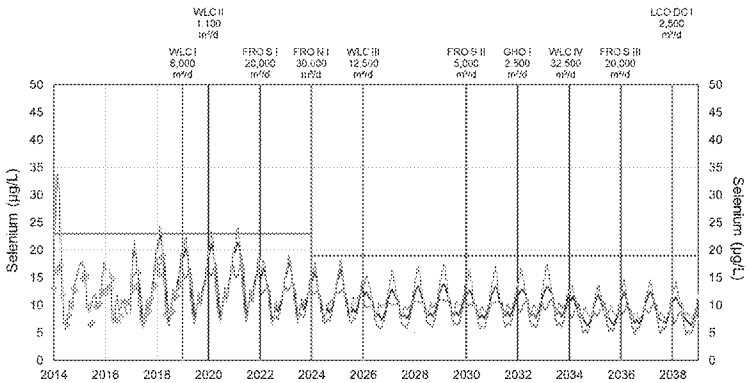
Projected Concentrations of Selenium at Four Order Stations (based on the 2019 Implementation Plan Adjustment)



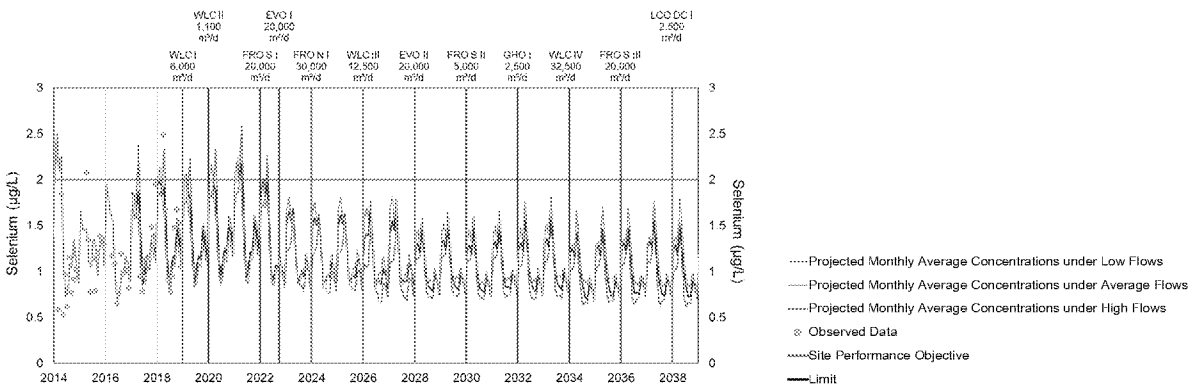
a) Fording River downstream of Greenhills Creek (GH_FR1)



b) Fording River downstream of Line Creek (LC_LC5)

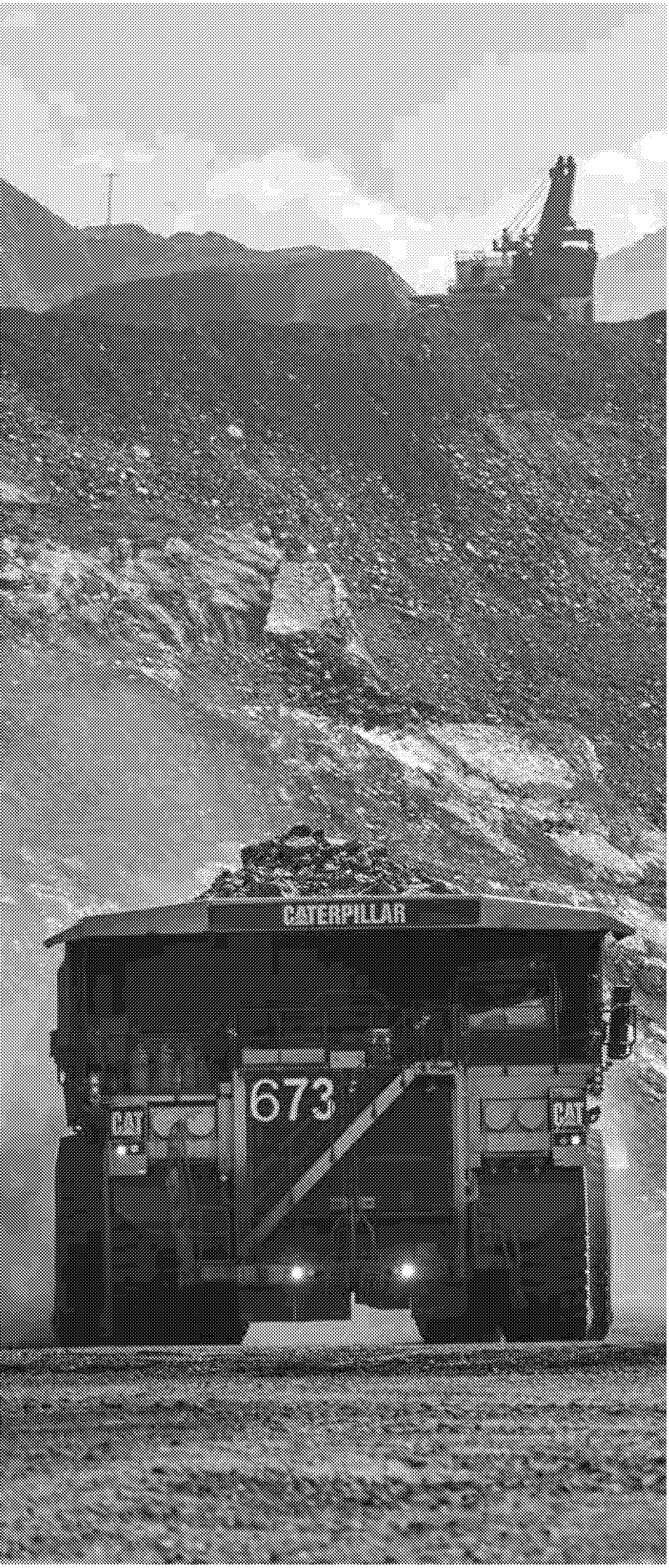


c) Elk River upstream of Grave Creek (EV_ER4)



d) Koocanusa Reservoir (RG_DSELK)

Figure 9. Projected concentrations of selenium at four order stations (based on the 2019 Implementation Plan Adjustment).



Nitrate

Nitrate is an organic compound made of nitrogen and oxygen. Nitrate is a key component of the explosives used in mining. It is carried by water from waste rock piles into streams and rivers. High concentrations of nitrate in the water may be harmful to fish and other aquatic organisms by disrupting their ability to use oxygen. This harms their growth and development, particularly during the early life stages (as larvae or eggs, for example). In humans, nitrates are a particular concern for babies and pregnant women. Exposure to high levels of nitrates reduces the amount of oxygen in the blood resulting in a condition called methemoglobinemia. High concentrations of nitrate in the water can also contribute to excessive plant growth (eutrophication).

Concentrations of nitrate in the Elk Valley have been increasing over time, but levels are currently below permit limits—except for two locations: the Fording River compliance point and the Line Creek compliance point (see page 15 in the *Compliance* section for more information). The Regional Water Quality Model projects that once the Fording River South Active Water Treatment Facility is operational (facility start up will commence late 2020 with a ramp up to full operation in 2021), nitrate concentrations in the Fording River will be below permit limits, with some seasonal variability (during some months the concentrations will not meet the limits). The Regional Water Quality Model projects that Teck will reach compliance with its nitrate limits in Line Creek by 2025 when the West Line Creek Active Water Treatment Facility is expanded (Figure 10).

Teck has made a significant effort over the past year across all operations to reduce nitrate loading in the receiving environment by increasing the use of plastic liners during blasting. Liners help to reduce the loss of explosive emulsion to fissures in the rock and improve combustion. This means less residual nitrate ends up in the waste rock. Because nitrate takes years to move through spoils, it will take time to measure the benefits of these improvements in Elk Valley waters. The EMC does not review or provide advice related to Teck's nitrate management activities.

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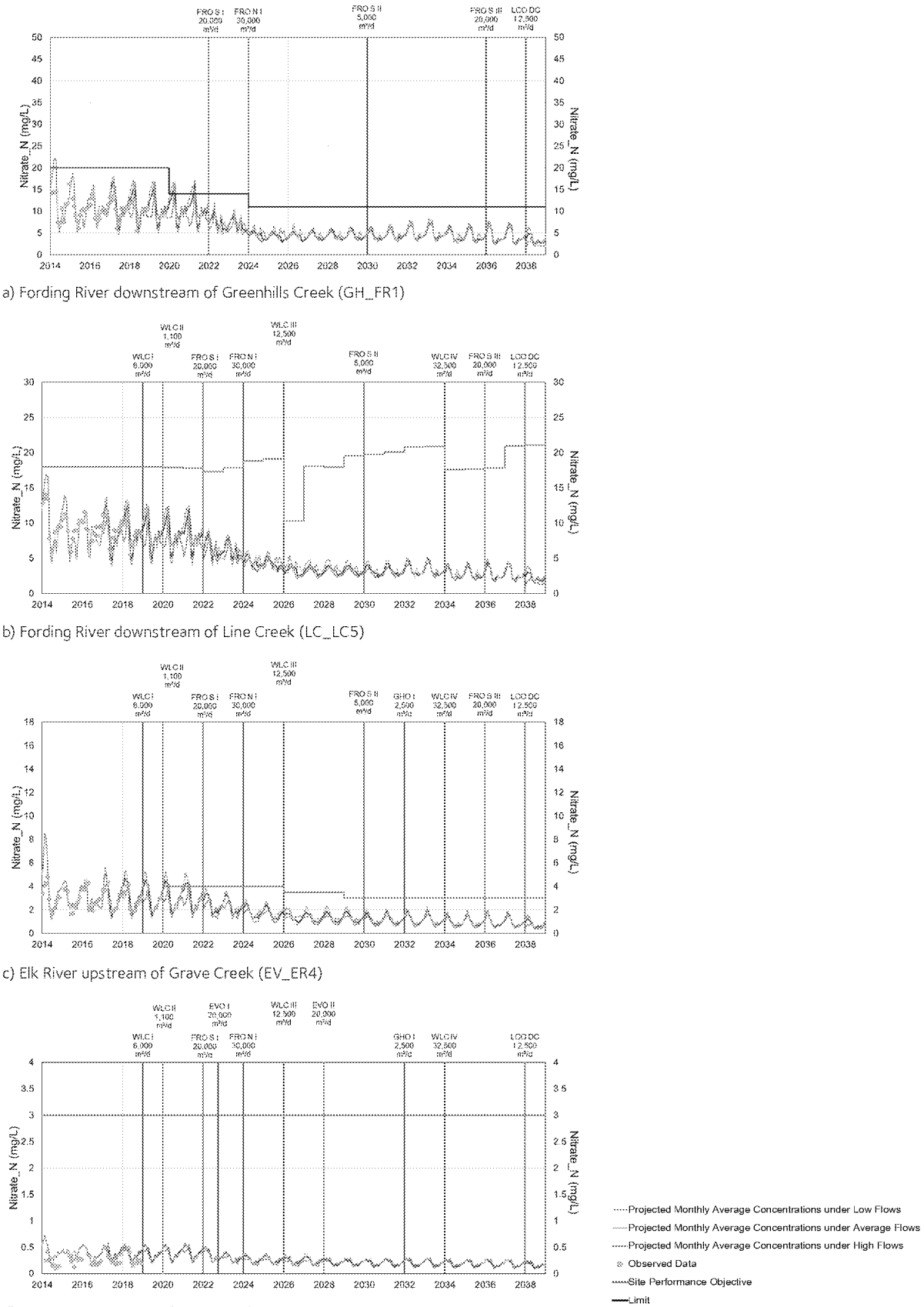
Projected Concentrations of Nitrate at Four Order Stations (based on the 2019 Implementation Plan Adjustment)



a) Fording River downstream of Greenhills Creek (GH_FR1)

b) Fording River downstream of Line Creek (LC_LC5)

c) Elk River upstream of Grave Creek (EV_ER4)

d) Koocanusa Reservoir (RG_DSELK)

Figure 10. Projected concentrations of nitrate at four order stations (based on the 2019 Implementation Plan Adjustment).

Sulphate

Sulphate is released from waste rock through the oxidation (exposure to oxygen) of minerals containing sulphide. When exposed to high sulphate in water, aquatic invertebrates experience impaired regulation of bodily fluids, and high sulphate levels can be harmful to fish and other aquatic organisms. Sulphates in humans may have a laxative effect (cause diarrhea) that can lead to dehydration; this is of particular concern for infants.

Concentrations of sulphate in the Elk Valley have been increasing over time, but have been below permit limits—with the exception of the Fording River compliance point (see page 15 in the *Compliance* section for more information). The concentrations of sulphate are projected to continue increasing, but they are projected to remain below permit limits—except at the Fording River compliance point and the Line Creek compliance point. Sulphate concentrations at the Fording River compliance point are projected to be above the permit limit by 2027 and at the Line Creek compliance point by 2026 (Figure 11).

There is uncertainty about the breadth of potential risks that projected sulphate concentrations may cause for aquatic life, so Teck was required to study the toxicity of sulphate to better understand this. The EMC provided input and review of this study (see page 41).

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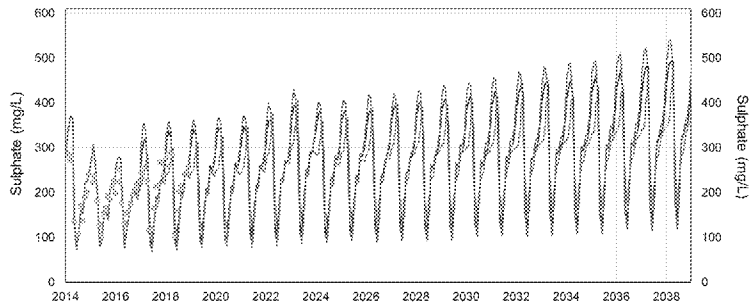
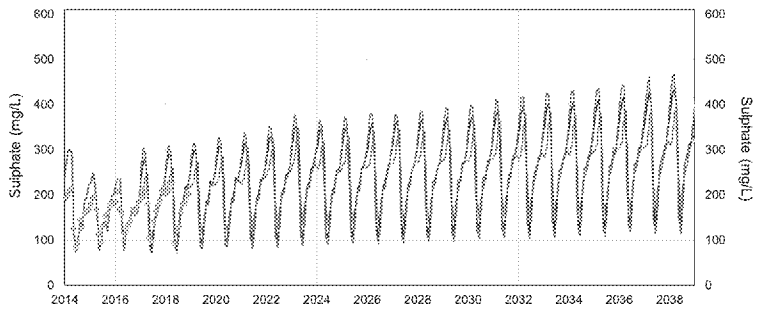
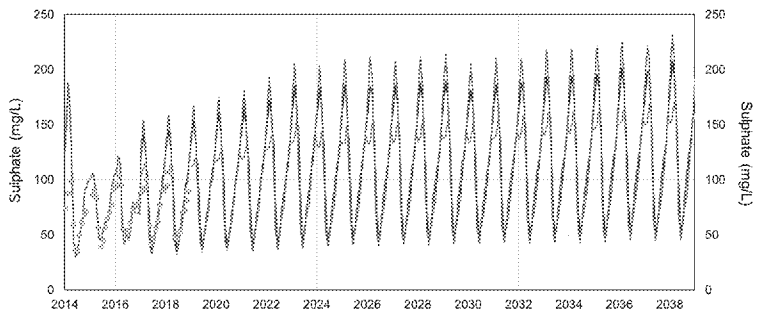
Projected Concentrations of Sulphate at Four Order Stations (based on the 2019 Implementation Plan Adjustment)



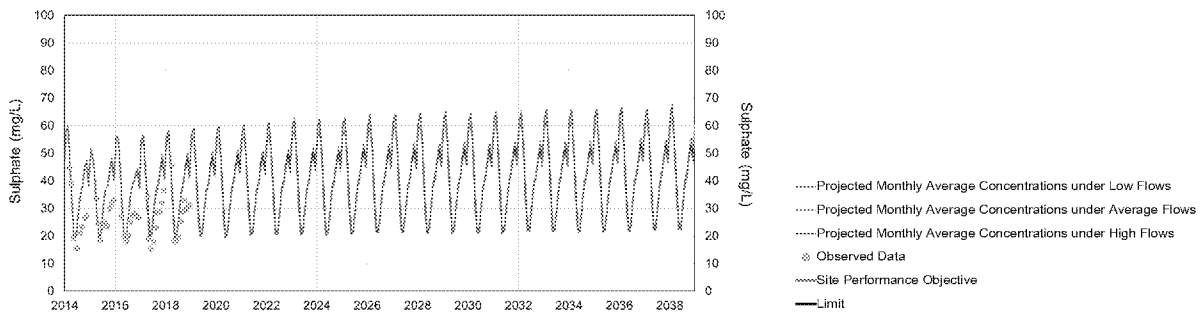
a) Fording River downstream of Greenhills Creek (GH_FR1)



b) Fording River downstream of Line Creek (LC_LC5)

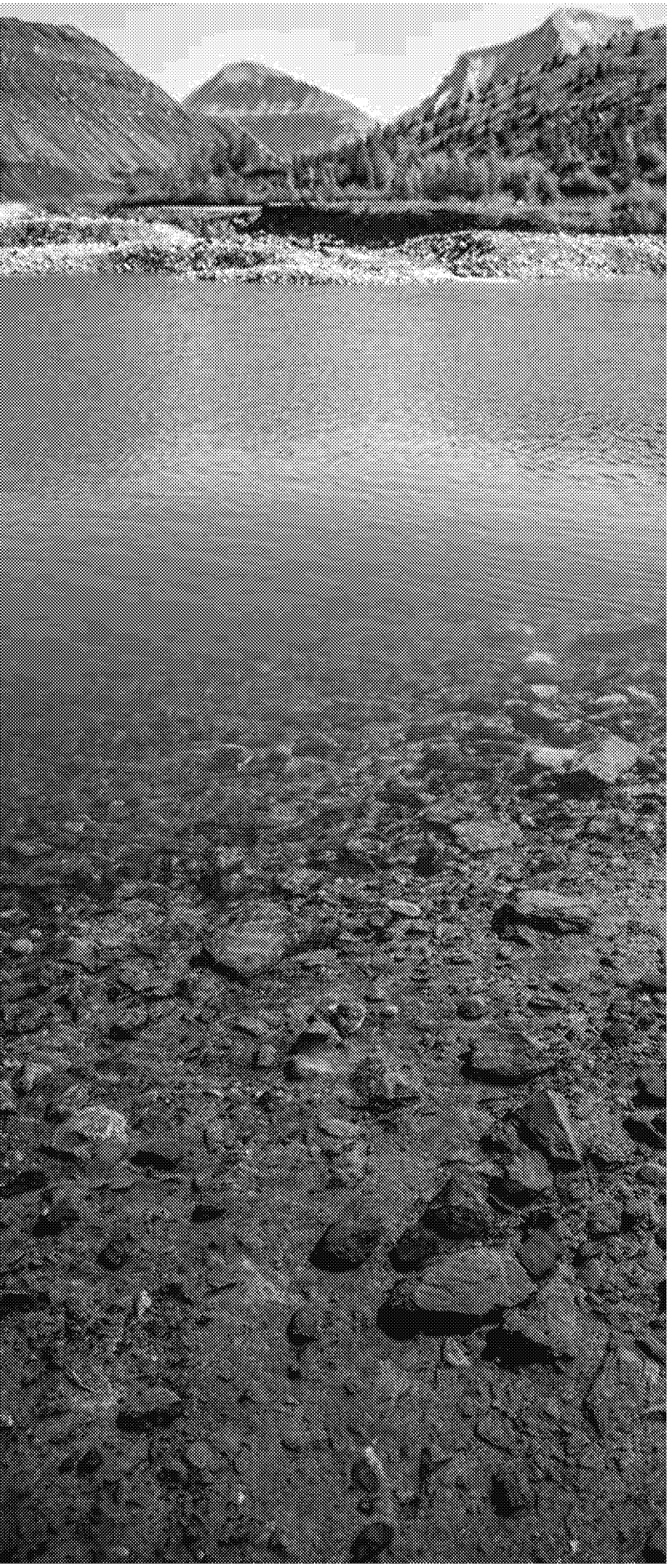


c) Elk River upstream of Grave Creek (EV_ER4)



d) Koocanusa Reservoir (RG_DSELK)

Figure 11. Projected concentrations of sulphate at four order stations (based on the 2019 Implementation Plan Adjustment).



Cadmium

Cadmium is a rare, naturally occurring metal formed from the mineral sphalerite. It is released during mining and it is found in the waste rock at certain locations in the Elk Valley. Cadmium can be harmful in aquatic environments at very low concentrations. At this time there is inadequate evidence to state whether or not cadmium has the potential to cause cancer from lifetime exposures through drinking water.

The permit limit for cadmium is the BC water quality guideline and this varies with water hardness. The guideline is approximately 0.6 µg/L when water hardness is 400 mg/L (upper Fording River) and approximately 0.35 µg/L when water hardness is 200 mg/L (in the lower Elk River). Concentrations of cadmium throughout the Elk Valley are below permit limits and do not appear to be increasing over time. There are some seasonal trends, but these appear to be driven by background conditions. There are elevated concentrations in some tributaries influenced by mining activities, but these concentrations are still below the permit limits. The concentration of cadmium at the order stations has been below 0.1 mg/L.

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Nickel

Nickel is a common, naturally-occurring metallic element. Although it does not accumulate in fish, plants, or animals, nickel does accumulate in soils and sediments and may have an adverse effect on aquatic life when concentrations are high in the water.

In the Elk Valley, nickel concentrations are below the BC guideline. The concentrations are higher at localized areas in Corbin Creek downstream of Coal Mountain Operations and in Michel Creek, but still remain below the guideline (Figure 12).

The BC guideline for nickel is 150 µg/L, but Teck—through additional monitoring programs—has measured adverse responses to sensitive benthic invertebrates at concentrations ranging from 5 to 22 µg/L. Teck notified ENV, EMC, EC, and KNC of this finding and continues to monitor and review the results with the EMC. Teck is currently working on developing an updated site-specific nickel screening value that will protect sensitive invertebrates. The EMC will be asked for input as this progresses. Teck is also evaluating water treatment options for nickel.

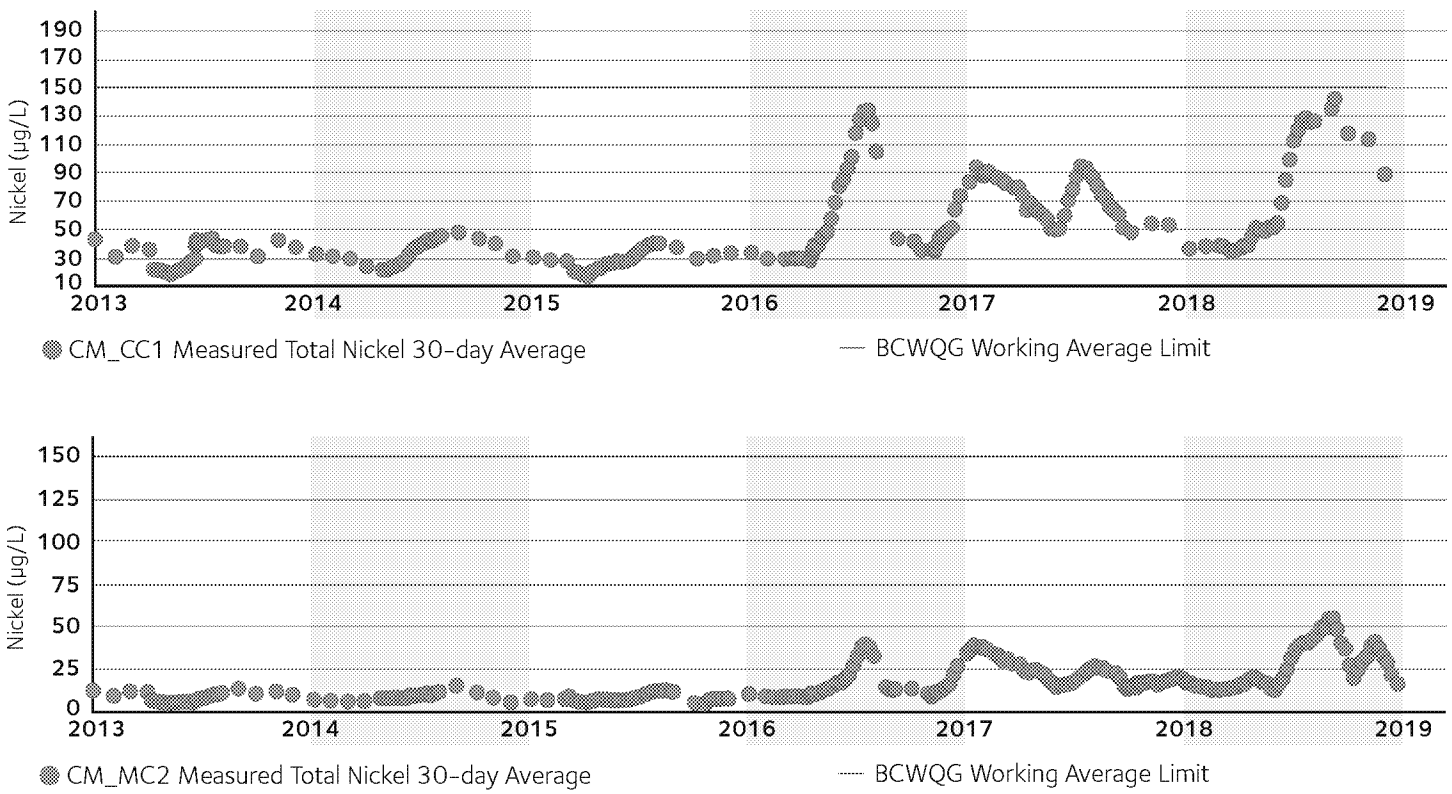

Figure 12. Concentration of nickel (in µg/L) in Corbin Creek downstream of Coal Mountain Operations (top) and in Michel Creek (bottom) since 2013. See map on page 8.

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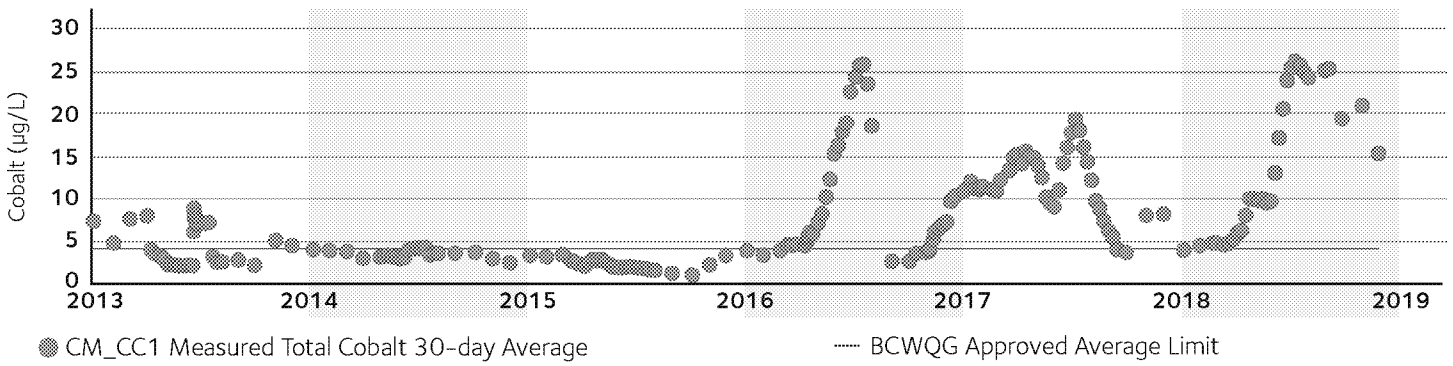
Cobalt

Cobalt is a naturally-occurring element that is found in small amounts in rocks, soil, water, plants, and animals, often combined with other elements. It is an essential nutrient for humans at low concentrations and is an important component of the vitamin B12. But like selenium, too much cobalt can have adverse health effects for humans, including serious impacts on the heart and thyroid.

The maximum concentrations of cobalt observed at a localized level in Corbin Creek downstream of the Coal Mountain Operations and in Michel Creek were below the BC guideline of 110 µg/L. But the long-term average was above the BC guideline of 4 µg/L, and concentrations have been increasing over time (Figure 13). Along with nickel, Teck is looking into water treatment options for cobalt.



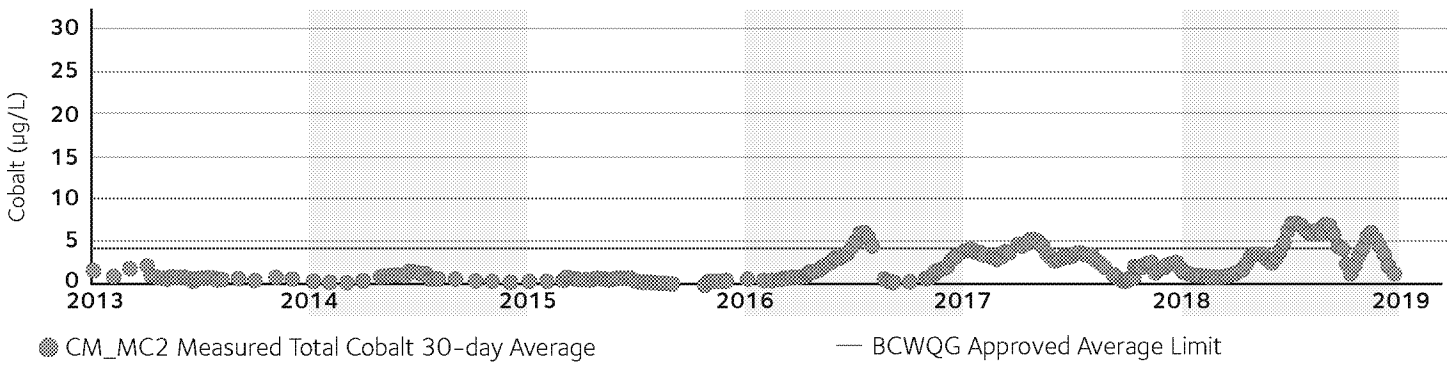


Figure 13. Concentration of cobalt (in µg/L) in Corbin Creek downstream of Coal Mountain Operations (top) and in Michel Creek (bottom) since 2013. See map on page 8.

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Calcite

Calcite is a common component of sedimentary rock, particularly limestone, and is made up of calcium carbonate – a calcium salt. Calcium carbonate is very common; it is the main building block of animal shells and is the white crust that builds up on the bottom of your tea kettle.

As water travels through rock (both underground and on the surface), calcite in the rock dissolves and the calcium carbonate is carried into streams and rivers. Here the calcium carbonate can recrystallize and form a thin layer of calcite on the streambed. This process does occur naturally in streams, but mining operations have the potential to increase the rate, extent, and depth of the formation of calcite when water passes through waste rock piles.

When that thin layer of calcite on the streambed builds up over time, it starts to form a calcite crust that can cement gravel and rocks together, degrading habitat for fish and aquatic insects. The degree of degradation can vary as shown in Figures 14 to 16.

Figure 15. A fully concreted streambed in Porter Creek. This reach has a calcite index of 3.

Annual Calcite Monitoring

Teck has been monitoring calcite levels in the Elk Valley annually since 2014. In 2018, 100 rocks at each of 312 sites on 117 stream reaches were surveyed, and 354 km of stream were assessed and mapped. The surveys measure the presence of calcite and the level of concretion (how cemented the rocks are to the streambed) to generate a calcite index between 0 and 3.

Calcite Index Value

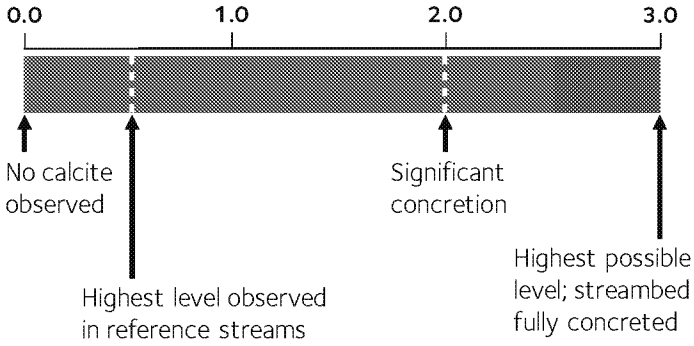

Figure 14. Range of values for the calcite index.

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Permit 107517 describes the site performance objectives for calcite in streams that are fish-bearing, provide fish habitat, or flow directly into fish-bearing streams:

- By December 2024, Teck must achieve calcite concretion of less than 0.50. This means at least 50% of rocks sampled within the reach have no concretion (are not stuck to the stream bed).
- By December 2029, Teck must achieve a total calcite index of less than 0.5. This is the level of calcite that is found naturally in streams unaffected by mining.

There has been an increase in calcite over time in the Elk Valley. The results show that the percent of kilometers with a calcite index between 0 and 0.5 is decreasing over time in both streams and creeks (tributaries) and in the Fording and Elk rivers (main stems), while the percent of kilometres in the main stems with a calcite index between 0.51 and 1.00 is increasing (Figure 16). The majority of mine-affected areas that Teck has sampled had low levels of calcite (calcite index values ranging between 0 and 0.5) and this is consistent with streams that have not been influenced by mining (reference streams). Of the 288 kilometres of mine-exposed rivers and tributaries surveyed in 2018, 85.8 kilometres (30%) of these are impacted by calcite at levels higher than background.[4]

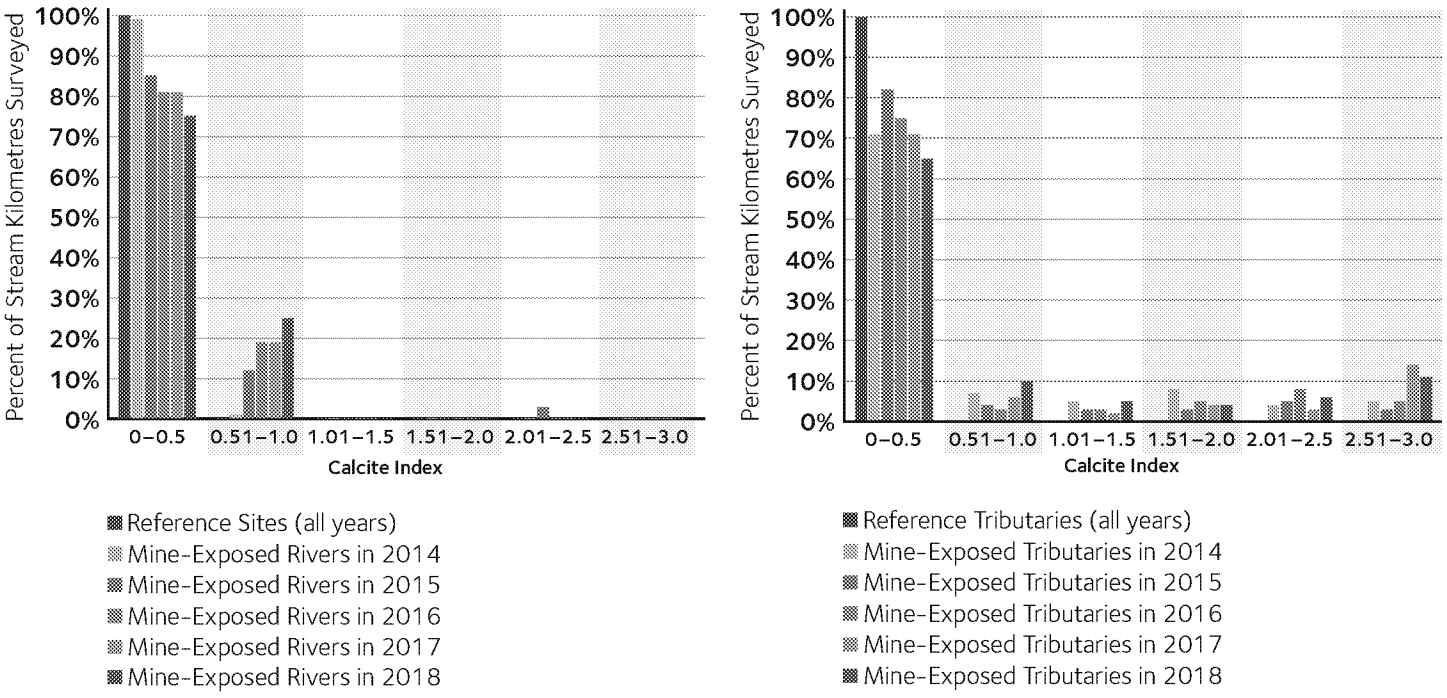

Figure 16. Calcite distribution (by percent of stream kilometres surveyed) in the Elk and Fording Rivers (left) and tributaries (right) from 2014 to 2018.

[4]Calcite Monitoring Program 2018 Annual Report

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Biological Effects of Calcite

Teck has been conducting studies since 2015 to learn about the potential effects of calcite on the aquatic environment. The first study focused on the effects of calcite in streams on aquatic insects (mayflies, stoneflies, and caddisflies) and algae. The results showed that the average percent of mayfly larvae in the insect community tended to decrease to below the regional reference normal range when calcite index values were above 1. However, areas having a calcite index greater than 1 also tended to have elevated concentrations of selenium, nitrate, and/or sulphate above benchmarks. Therefore, the effects of calcite could not be distinguished from those associated with water quality (that is, in areas where effects are observed, the effects may be due to calcite or water quality, or both, depending on the area).

The second phase (2016 and 2017) of the study focused on the relationship between calcite index and incubation conditions for fish eggs laid in the gravel on the bottom of the streams. While calcite was found to have some effect on the amount of oxygen available in the gravels, the effects on incubation conditions are predicted at depths deeper than the typical depths of the eggs and at sites with calcite concretion that may prevent fish from being able to dig their nests (redds). The third phase of the study (2018) focused on finding a link between calcite formation on the streambed and the suitability of spawning habitat for Westslope Cutthroat Trout (measured by the presence of redds and the density of redds within a stream). In five streams sampled within the upper Fording River watershed, redds were found across the full range of calcite index values up to 1.7. However, the current data suggests there may be an influence of calcite on redd density. These results are preliminary and are based on a small sample size, so more study is needed to better understand the effect of higher calcite index values on redd presence (are they there?) and density (how many are there?).

What is a redd?

A redd is a fish nest. Certain species of fish—like trout and salmon—use their tails to scoop out a hollow in the gravel of a streambed. The female lays her eggs in this hollow, the male fertilizes them, and the female covers the eggs with gravel.

Managing Calcite

Teck is required to manage the formation of calcite and reduce calcite levels in mine-affected streams in the Elk Valley. Since October 2017, Teck has been applying antiscalant (a chemical compound that prevents calcite particles from forming) in Lower Greenhills Creek to prevent new calcite from forming on the streambed. The calcite index value in 2018 for Lower Greenhills Creek has not changed from 2017 suggesting that the antiscalant is successful in preventing new calcite from forming. However, based on recent research, antiscalant does not remove existing calcite from the streambed. Teck will continue to pursue other technologies for removing calcite.

Teck is also required to monitor water quality and aquatic effects downstream of any calcite treatments. Monitoring results from 2018 showed no negative effects on water quality in, or downstream, of Lower Greenhills Creek, and showed no toxicity effects related to the antiscalant. Teck will continue monitoring this calcite treatment system to better understand its effectiveness and to determine what the results might mean for calcite treatment in other creeks.

The EMC doesn't review studies or plans related to calcite management, but it does review the results of the water quality and aquatic monitoring that Teck conducts downstream of calcite treatments.

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Groundwater Quality

In the Elk Valley, groundwater generally flows below the surface in shallow sand and gravel aquifers, parallel to streams and rivers (surface water). Mining influences on groundwater can occur through two main pathways (Figure 17):

- Groundwater pathway: Mine-related substances infiltrate the ground from mine sources (such as waste rock, process plants, and settling ponds) and influence aquifers close to mining operations. In areas where this is the main pathway, concentrations of mine-related substances in groundwater are expected to be higher than in nearby surface water.
- Surface water pathway: Mine-influenced surface water interacts with aquifers in the valley bottoms. In areas where this is the main pathway, concentrations of mine-related substances in groundwater are expected to be equal to or less than nearby surface water because of mixing with freshwater sources.

The surface water pathway is believed to be the main pathway for transporting mine-related substances to groundwater on a regional scale. The majority of groundwater receptors (drinking water, livestock, and wildlife) are influenced by this pathway in the valley-bottoms. As surface water quality improves through treatment, groundwater quality is also expected to improve.

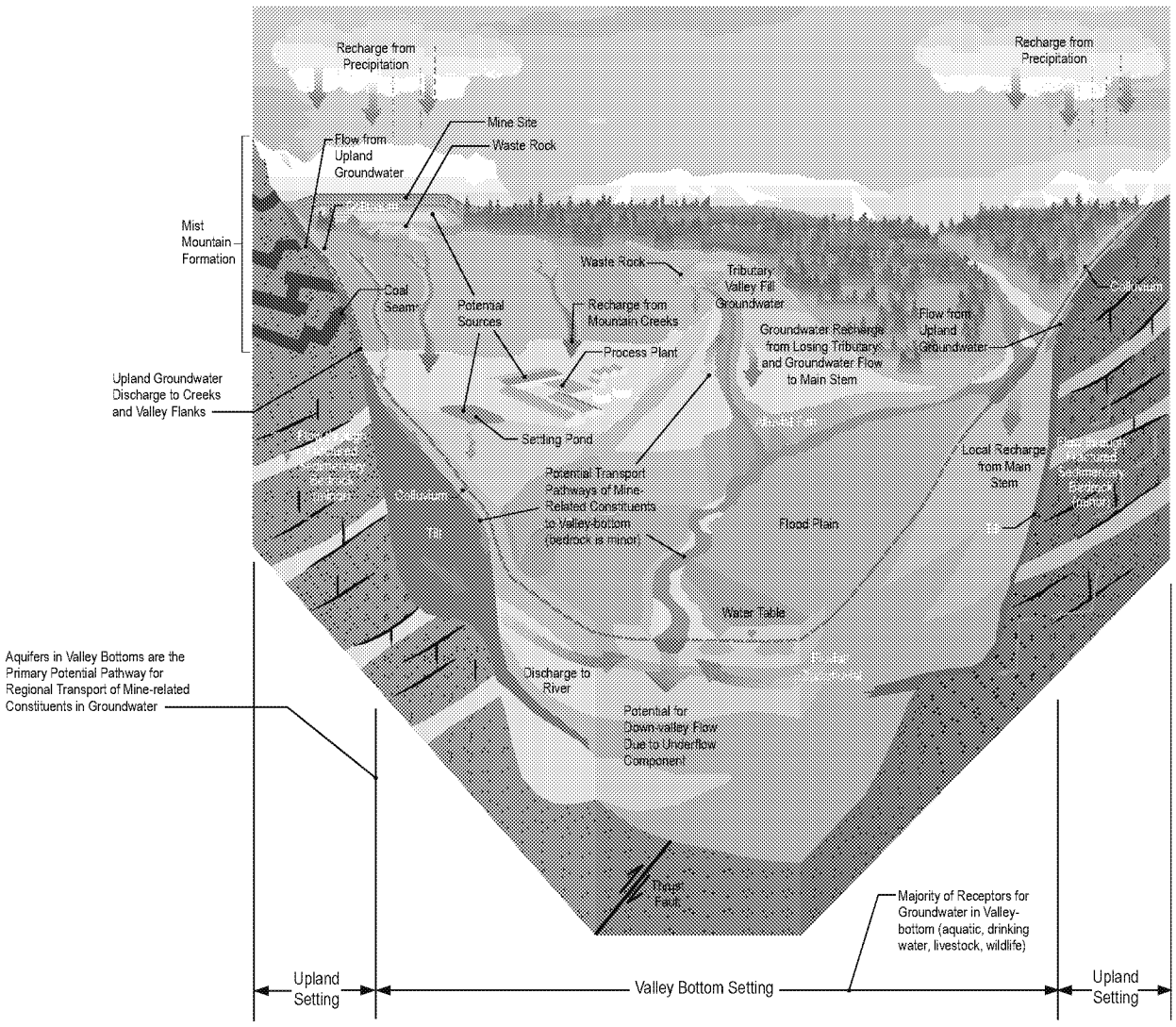

Figure 17. Pathways for mining influences on groundwater.

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What is an aquifer?

An aquifer is a geological formation where groundwater can flow and be stored. Aquifers can be located right below the ground surface or very deep underground. They can be very large or quite small. They consist of layers of sand, gravel, or bedrock that is saturated with water.

To better understand the potential effects of mining operations on groundwater and the interactions between surface water and groundwater, Teck carries out six monitoring programs in the Elk Valley. There are five site-specific groundwater monitoring programs (one at each mine operation) and a regional groundwater monitoring program. The site-specific programs focus on the potential sources of mine-related substances and identify the transport pathways to the valley bottoms of the Elk River, the Fording River, and Michel Creek. The regional program focuses on the groundwater flow paths within the valley bottom and how they relate to the receptors. The EMC reviews and provides advice on the regional program. There is a groundwater working group that is linked to the EMC, which provides particular expertise on this topic.

The regional groundwater monitoring program identified twelve study areas in the Elk Valley where there may be transport of mine-related substances to groundwater in the valley bottom. Every three months Teck collects water samples and groundwater elevations from 37 wells in the study areas. The water samples are analyzed in a laboratory and the results are compared against BC guidelines for drinking water, aquatic life, livestock, and irrigation (primary screening criteria) and site performance objectives and compliance point concentrations for selenium (secondary screening criteria). Groundwater chemistry is compared to chemistry at nearby surface water stations to increase understanding of surface water and groundwater interactions. Measuring groundwater levels helps to understand groundwater flow direction and seasonal changes in aquifer storage.

Teck now has four years of regional groundwater results. In general, results from 2018 (Figure 18 and 19) were relatively similar to previous years.

Sparwood Area Groundwater Study

Teck's monitoring program identified elevated concentrations of mine-related substances, primarily selenium, in groundwater in the Sparwood Area. Teck has been conducting a special groundwater study in the Sparwood area to identify the potential sources and pathways of mine-related substances in drinking water.

In 2018, Teck reviewed all the domestic wells in the Sparwood Area and analyzed how groundwater could be affected by mining activities. The analysis confirmed that mine-influenced groundwater exists in some aquifers and suggested that the source of mine-related substances was likely from groundwater flowing through the Michel Creek valley bottom rather than directly from Baldy or Sparwood Ridge. Seven new wells were drilled in the Sparwood Area to address these gaps in our understanding of the groundwater flow paths.

Teck's Drinking Water Monitoring Program

Teck offers private well owners in the Elk Valley the opportunity to have their water tested for mining-related substances. Well owners along Michel Creek, the Fording River, and the Elk River should be aware that concentrations of some mine-related substances may be elevated, especially when creeks and rivers have low flow. Teck shares the laboratory results with well owners and regulatory agencies, but they are otherwise confidential. The laboratory results are compared to the BC drinking water quality guidelines. If the results are above background levels but below the BC water quality guidelines, Teck will continue to sample the well annually or every three months, depending on the results. If the results are above guidelines for mine-related substances, Teck provides alternate drinking water and continues routine monitoring.

In 2018, four of the thirteen wells that were sampled routinely as part of this program had concentrations of selenium temporarily above the BC drinking water guideline of 10 µg/L.

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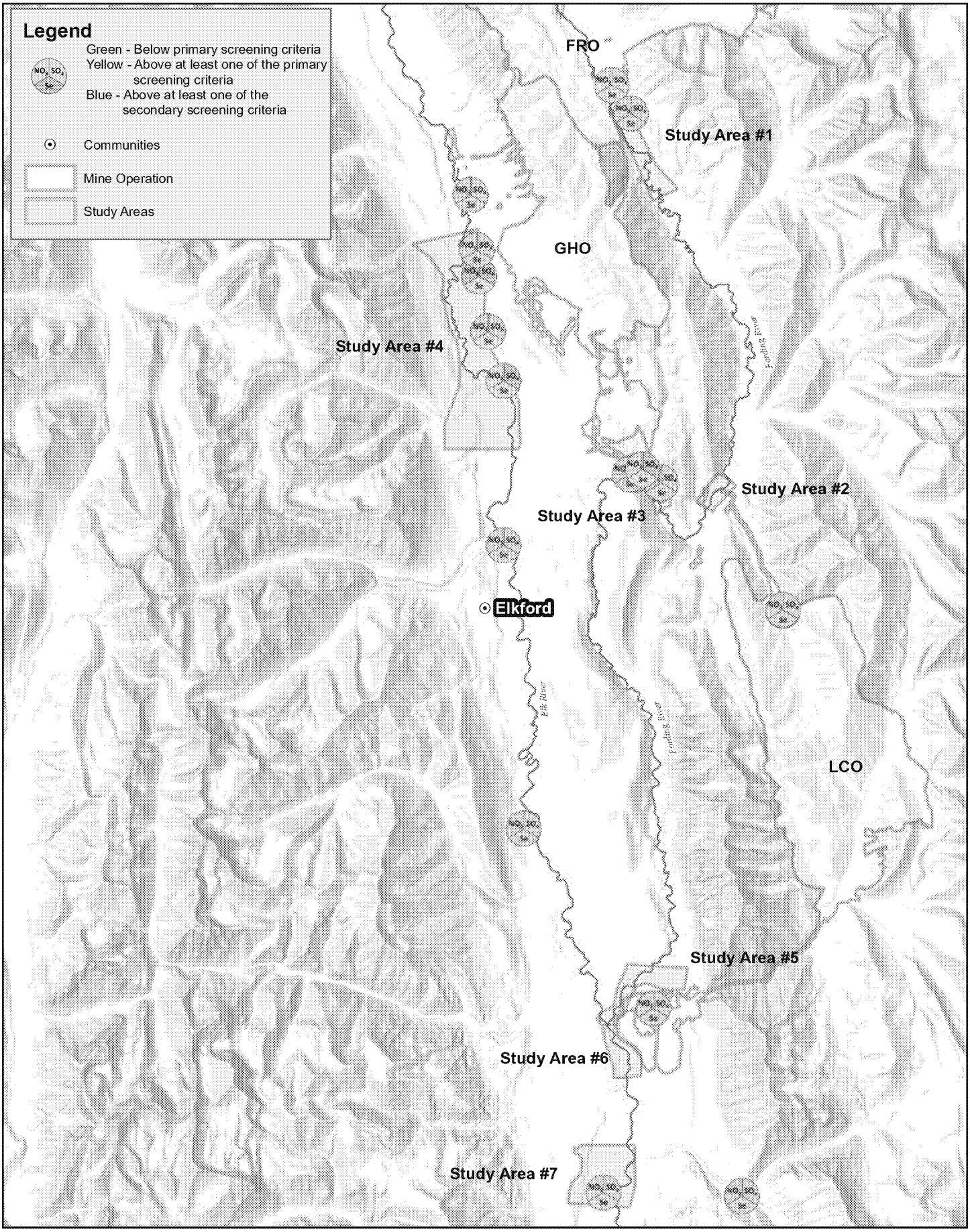

Figure 18. Results from the 2018 groundwater monitoring program (north valley).

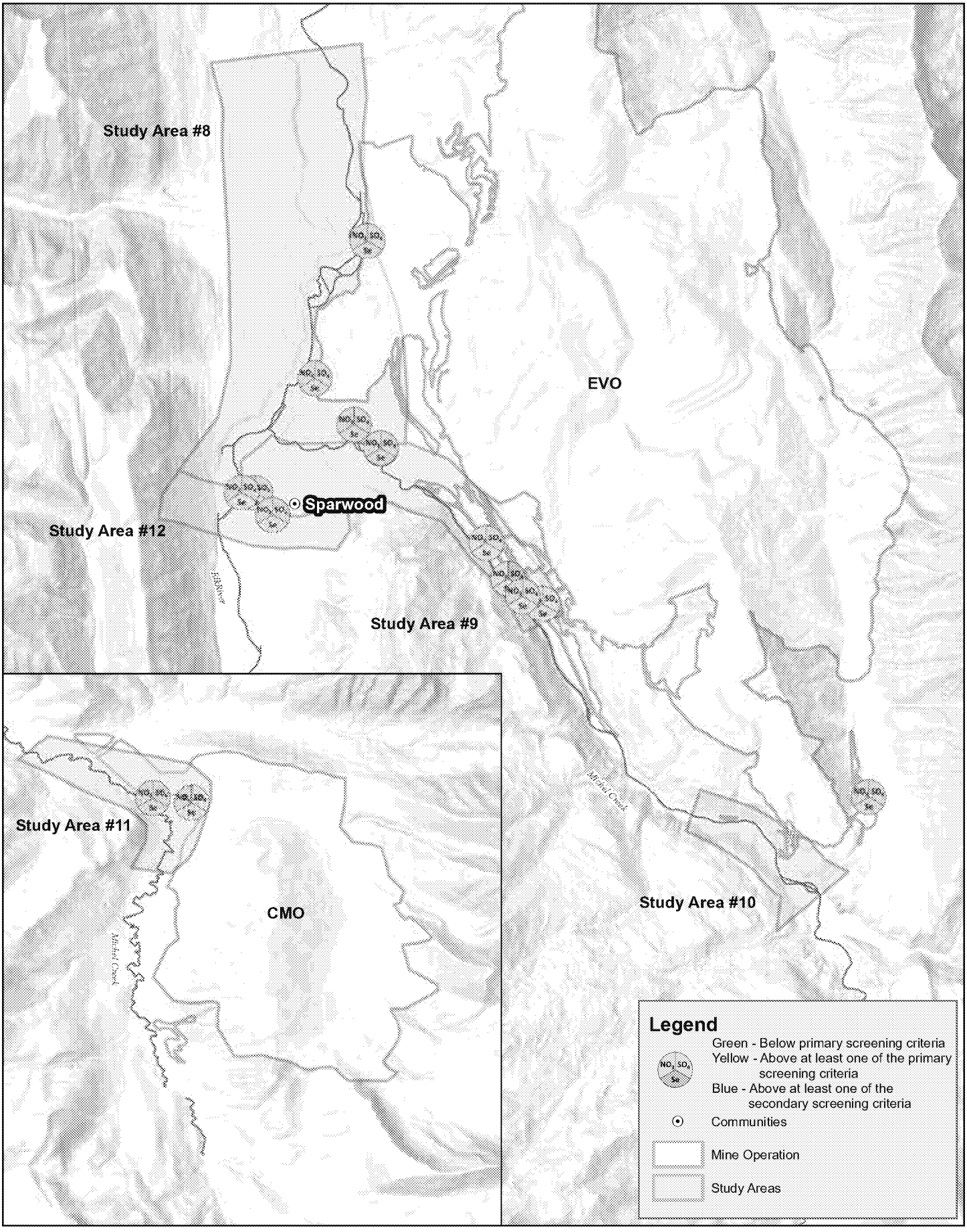

Figure 19. Results from the 2018 groundwater monitoring program (south valley).

Effects on Aquatic Life

Regional Monitoring

Teck's Regional Aquatic Effects Monitoring Program (RAEMP) is a valley-wide program that looks at the biological effects of water quality on aquatic organisms, specifically benthic invertebrates and fish. Routine field sampling occurs every year, and the results are analyzed and shared with the EMC as they are generated. A RAEMP report is developed every three years. The purpose of this program is to:

- assess the effects of mine operations, individually and together, on aquatic ecosystems within the Elk River watershed
- monitor changes over time
- help understand whether Teck's management and mitigation actions are working as intended by the Elk Valley Water Quality Plan and Permit 107517

Teck completed the first comprehensive cycle of field sampling in 2015 and a subset of sampling in 2016 and 2017 in target areas. The first RAEMP report was submitted to the Director in September 2017.[5]

In March 2018, Teck developed a new study plan for the 2018 to 2020 RAEMP cycle. Based on advice from the EMC, Teck added five new studies to better understand:

- lentic areas (locations with slower moving water)
- reproductive effects of selenium on the Columbia Spotted Frog
- reproductive effects of selenium on the fish, Redside Shiner
- toxicity in sediment
- nutrient loading from mine-related sources and active water treatment facilities

Teck completed the second comprehensive cycle of sampling in 2018. This included benthic invertebrate sampling at 69 locations and fish sampling at 18 locations: 11 for Westslope Cutthroat Trout and 7 for Mountain Whitefish.

The results from the routine sampling and the additional studies will be included in the RAEMP report submitted to the Director and the EMC in September 2020.

[5] Regional Aquatic Effects Monitoring Program 2015-2016 Report

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Benthic Invertebrates

Benthic invertebrate communities in the flowing portions of the Elk River and its tributaries are dominated by mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). These three aquatic invertebrates are collectively called EPT. EPT are considered highly sensitive to changes in water quality and habitat disturbance. When EPT are abundant, it indicates good quality habitat for aquatic organisms.

Of the 46 mine-exposed areas sampled in 2018, five had EPT abundances less than the normal range observed in reference (not mine-exposed) tributaries. Results from 2018 again showed a reduction in the proportion of three types of mayflies in the upper part of the Fording River. The extent and cause of this reduction cannot be explained by water quality or calcite effects alone and may be due to both mine-related and natural factors. Teck is continuing to investigate this under the Fording River Operations Local Aquatics Effects Monitoring Program (page 39).

The selenium concentrations in the tissues of benthic invertebrates collected in fast-moving waters have typically been less than what is considered to have a 10% effect on benthic invertebrate reproduction (this is called the Level 1 benchmark). The preliminary results from 2017 and 2018 indicate that 8 out of 76 areas sampled (9.2%) had one sample or more with a selenium concentration greater than the Level 1 benchmark for benthic invertebrates. Accumulation in these areas was expected given the projected selenium concentrations for these areas in the EVWQP. The concentrations of selenium in benthic invertebrates from slow-moving water have frequently been greater than the Level 1 benchmark. You can find more information about the benchmarks, and how they were derived, in the Elk Valley Water Quality Plan (EVWQP).

The tissue results were compared to normal ranges in reference tributaries and to water quality and bioaccumulation models that were developed for the EVWQP. In 2017 and 2018, tissue selenium concentrations measured in benthic invertebrates from 72.3% of the mine-exposed areas (47 of the 65 areas sampled) were above the upper end of the normal range of reference tributaries.

The tissue selenium concentrations in benthic invertebrates were generally within the range predicted by the bioaccumulation model presented in the EVWQP in all study areas, except for Bodie Creek and Dry Creek near Line Creek Operations. Bodie Creek was receiving water pumped from mining pits that had forms of selenium more easily accumulated, which led to higher selenium concentrations in benthic invertebrates. In Dry Creek, tissue concentrations are uncharacteristically high and Teck is evaluating the different forms of selenium. The EMC will continue to review this information and provide input through the Dry Creek Local Aquatic Effects Monitoring Program.

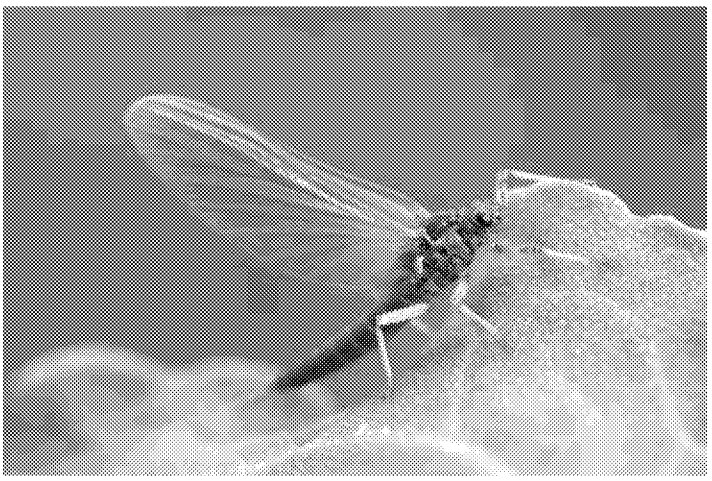

Figure 20. Mayfly (Ephemeroptera)

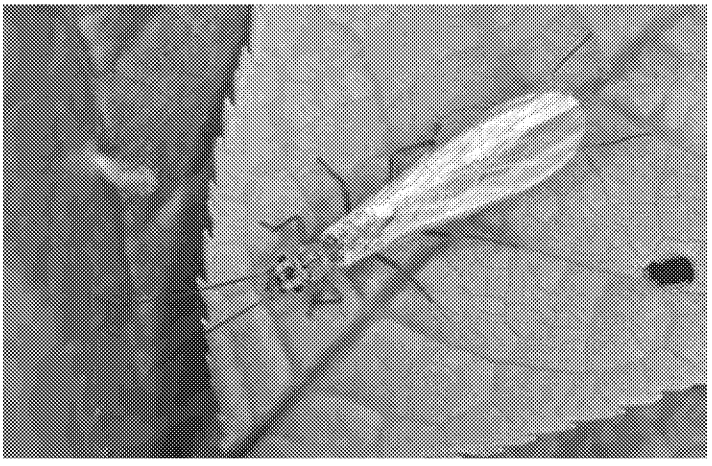

Figure 21. Stonefly (Plecoptera)

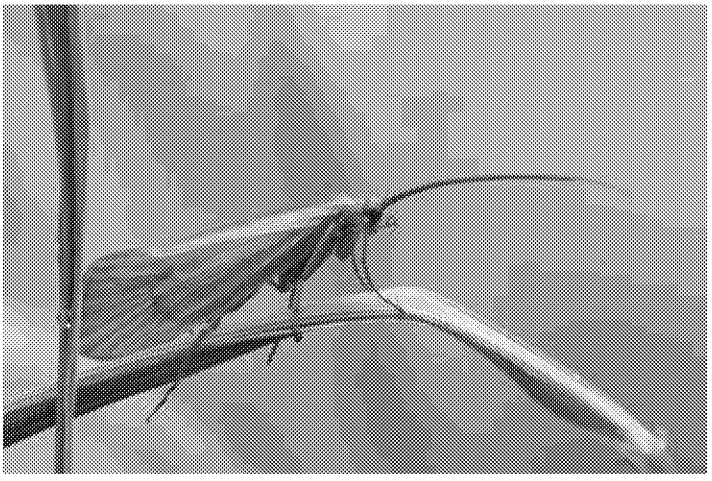

Figure 22. Caddisfly (Trichoptera)

Fish

In the first cycle of the RAEMP (2015 to 2016), Teck studied three species of fish that are common in the Elk Valley: Westslope Cutthroat Trout, Mountain Whitefish, and Longnose Sucker.

Westslope Cutthroat Trout are widely distributed throughout the Elk River watershed and are the only fish present in the Fording River upstream of Josephine Falls. Teck sampled fish from the Elk and Fording Rivers in 2015 and again in 2018. Samples were obtained by taking a very small amount of muscle, called a plug. Fish are then released.

Preliminary results from the September 2018 sampling events indicate that nearly all of the fish sampled had selenium concentrations near or above the upper limit of the normal range observed in reference-area fish. These results are similar to those from 2015. However, these tissue concentrations were within the ranges projected by the bioaccumulation models developed for the EVWQP. All the fish collected from fast-moving water had selenium concentrations less than the Level 1 benchmark for reproductive effects, except for the fish from Line Creek. You can find more information on this topic on page 39).

Teck also conducts an annual population study on Westslope Cutthroat Trout in the Fording River. This study is not a permit requirement, but the results are shared with the EMC. The 2017 results indicated that the population was stable and potentially increasing[6]; however, preliminary results from September and October 2019 showed a very concerning decrease in juvenile and adult Westslope Cutthroat Trout density estimates compared to 2017. These findings are being evaluated under the adaptive management framework and Teck is involving all regulatory agencies. The EMC will be provided information on the evaluation.

Mountain Whitefish are found mainly in the Elk River and in the lower reaches of the Fording River, Line Creek, Alexander Creek, and Michel Creek. Samples were collected in 2015 and 2018 and analyzed for selenium concentrations.

Fifty-six mountain whitefish were euthanized in 2018 to obtain both muscle and ovary tissue samples. Eight locations were sampled, including two reference locations and six mine-influenced locations. The concentration of selenium in muscle tissue was higher than the BC water quality guideline for aquatic life for fish collected from the six mine-influenced locations. The concentration of selenium was below the guideline for fish collected from the reference locations. The concentration of selenium in the ovary tissue was higher than the guideline at both the reference and the mine-influenced locations. For fish collected at four of the six mine-influenced locations, the concentration of selenium in ovary tissue was above the interim screening value proposed by Teck (29.3 mg/kg dw). Teck and the EMC are discussing redoing the study to better understand the potential consequences of elevated selenium levels to Mountain Whitefish.

What is mg/kg dw?

The abbreviation *mg* stands for milligrams, *kg* stands for kilogram, and *dw* stands for dry weight. So a selenium concentration of 11 mg/kg dw means there is 11 milligrams of selenium per kilogram of dry fish tissue.

Dwarf Longnose Suckers are found in slow-moving waters throughout the Elk Valley. Teck collected tissue samples from fish in 2015 (from six locations) and 2018 (from Goddard Marsh only) and analyzed them for selenium concentrations. More intensive sampling will be carried out in fall 2019.

In the six mine-exposed areas sampled in 2015, the concentration of selenium was greater than for those fish collected from reference areas. The concentrations of selenium in ovary and muscle tissues were above the Level 1 benchmarks for reproductive effects for all individuals from Goddard Marsh, some of the fish from the Elk River wetland (downstream from Grave Creek), and some of the fish in Stanford Pond (near Fernie). The results from 2018 indicate that concentrations are increasing and Teck is discussing a selenium effects study on this species in the next few years. The results from 2019 will be shared with the EMC for their review and advice, and will be reported in the RAEMP 2020 report.

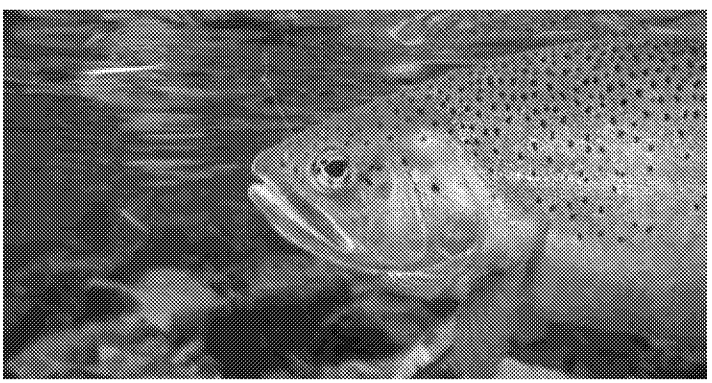

Figure 23. Westslope Cutthroat Trout

[6] Upper Fording River Westslope Cutthroat Trout Population Monitoring Project 2012 to 2017

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Local Monitoring

Local aquatic effects monitoring programs are designed to answer specific questions about aquatic effects that arise because of the unique circumstances of a particular mine operation and that cannot be answered using only the regional aquatic effects monitoring program. Teck currently has five local aquatic effects monitoring programs underway.

Fording River Operations

The local aquatic effects monitoring program at the Fording River Operations began in 2016. The intent of this program is to document current conditions and evaluate the aquatic effects of mine development and the planned active water treatment facilities (two active water treatment facilities are required by Permit 107517). The first three years of monitoring results are required to understand aquatic conditions before treatment so changes could be measured as the treatment facilities come online. The Fording River South Active Water Treatment Facility is currently under construction; commissioning is planned for late 2020. This facility will treat water from Cataract Creek, Swift Creek, and Kilmarnock Creek.

Results from the past three years showed a decrease in the abundance of mayflies in the upper Fording River at specific locations. The results from Teck's investigations do not point to a single direct cause. The decrease in abundance is likely due to a combination of both mine-related and natural factors (such as mine-related water quality concentrations of selenium, nitrate, and nickel; water temperature variability; annual flow variability; and predation by other organisms). Because sections of the upper Fording River flow underground at certain times of the year, the 2019 monitoring program will assess how benthic invertebrate communities re-establish after a drying event.

The program will continue to address the key questions related to the effects from Fording River Operations and the active water treatment facilities as they are commissioned.

Greenhills Operations

The local aquatic effects monitoring program at Greenhills Operations began in 2017 to gain a better understanding of the side channel that lies between Greenhills Operations and the Elk River. This side channel receives flow from Thompson Creek, Wolfram Creek, Leask Creek, and Mickelson Creek.

Results from 2017 and 2018 indicated that the side channel is used by a variety of fish and birds, from spring through fall when the side channel has flowing water. Seasonal drying of the side channel makes it poor habitat for amphibian breeding. Water quality in the side channel is influenced by Wolfram Creek and Thompson Creek, resulting in concentrations above the EVWQP Level 1 benchmarks (>10% effect size) for fish. Selenium concentrations in benthic invertebrates were higher in the side channel than in the mainstem of the Elk River, but the community endpoints did not differ greatly. In Thompson Creek and the downstream wetland, selenium concentrations in benthic invertebrates were above the EVWQP Level 2 benchmarks (> 20% effect size) for fish and birds.

The study design for 2019 takes a more focused look at water quality in the west-side tributaries, the side channel, and the mainstem of the Elk River. It will also look at groundwater-surface water interactions in the side channel and will continue monitoring the benthic invertebrate community and tissue chemistry to support answering the outstanding key questions of the program.

Line Creek Operations

There are two local aquatic effects monitoring programs at Line Creek Operations. The first began in 2014 to understand the potential effects of the West Line Creek Active Water Treatment Facility on water quality and aquatic organisms. Teck built the facility to reduce the concentration of selenium and nitrate in Line Creek. This facility is required by Permit 107517 and is the first of its type in the Elk Valley.

The facility was operational from July to October 2014. It was shut down because of performance issues until late 2015. Water quality monitoring results from 2016 and 2017 indicated that the facility was removing 95% of the total selenium and 90% of the nitrate from the water. However, biological monitoring results showed elevated concentrations of selenium in the tissues of aquatic organisms collected in Line Creek immediately downstream of the facility. An investigation determined that the treatment process was converting the remaining selenium in water to a form that is more easily accumulated by aquatic organisms. The facility was again shut down from March to August 2018 while Teck added an advanced oxidation process to the facility to address the selenium conversion.

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The temporary shutdown of the treatment facility in 2018 did not result in changes to the kinds, proportions, or numbers of benthic invertebrates in Line Creek. As predicted, results from 2018 indicate that selenium concentrations in aquatic biota decreased when the active water treatment facility was recommissioned with the advanced oxidation process. Monitoring in 2019 will confirm these results. This program continues to monitor water quality and aquatic organisms downstream of the facility to monitor the effectiveness of the treatment facility.

A second local aquatic effects monitoring program at the Line Creek Operations also began in 2014. This program was designed to determine the effects of the Line Creek Phase II project on the Dry Creek drainage by evaluating the potential effects of mine-related substances on aquatic biota. This program is required under a different permit (Permit 106970), but it was brought to the EMC for their review and advice early in 2019 through the adaptive management framework.

The first three years of annual monitoring results (2014 to 2017) showed little change in the conditions of the three creeks within the Dry Creek drainage: Dry Creek, Grace Creek, and Unnamed Creek. In May 2017, the concentrations of nitrate, selenium, and sulphate increased. Nitrate concentrations were above the Level 1 benchmark for potential effects to aquatic biota, while the concentrations of selenium, sulphate, and cadmium were below this benchmark. Selenium concentrations in benthic invertebrates were similar in upper and lower Dry Creek and benthic invertebrate communities were not adversely affected. In 2018, results showed another increase in the concentrations of mine-related substances in Dry Creek and both the rate and magnitude of change was faster than what was projected by the Regional Water Quality Model. Another unexpected finding in 2018 was elevated concentrations of selenium in benthic invertebrate tissue samples collected in Dry Creek. These concentrations were 5 to 10 times greater than what was measured in 2017. Teck has been investigating these unexpected observations and has added four monitoring locations in the latter part of 2018 and increased monitoring frequency. Toxicity test results conducted in 2018 showed a low potential for direct effects to aquatic life. Despite the changes in water quality in Dry Creek, and the unexpected selenium concentrations in the benthic invertebrates, benthic invertebrate communities were similar between upper and lower Dry Creek in 2018.

Elkview Operations

There are currently no site-specific issues or questions at Elkview Operations that require a local aquatic effects monitoring program. If a specific issue or question arises that cannot be addressed by the regional program monitoring, Teck will work with the EMC to develop a local program.

Coal Mountain Operations

The first year of local aquatic effects monitoring at the Coal Mountain Operations was 2019. This monitoring program was required by Permit 107517 because of results coming out of the regional monitoring program, Coal Mountain Operations management plans, and the routine laboratory tests for toxicity (bioassays). This program also supports the closure plans for Coal Mountain Operations. Results from the regional monitoring program, Coal Mountain Operations management plans, indicated that the benthic invertebrate community in Corbin Creek downstream of the Coal Mountain Operations and in Michel Creek displayed reduced numbers of certain species when compared to the reference sites. Results from the routine bioassays showed that water from Michel Creek was having a negative effect on certain test species. Teck launched an investigation into these results and found that nickel may be the cause, even though concentrations were below the BC water quality guideline. See the *Nickel* section on page 27 for more information.

The 2019 program will focus on water and sediment quality, calcite index, and benthic invertebrate tissue and community metrics. These results will help answer key questions about the magnitude and spatial extent of effects from the closure activities, such as pit pumping.

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Bioassay Studies

Bioassays are laboratory tests that involve exposing certain organisms (such as very young fish, water fleas, amphibians) to water or sediment collected from a monitoring location, and observing growth, reproduction, and survival of individuals. Teck routinely tests waters from various creeks in the Elk Valley and from the Fording and Elk rivers. In 2018, Teck also undertook detailed laboratory tests to understand the sensitivities of invertebrates, amphibians, and fish to mine-related substances.

Routine Laboratory Tests

Short-term laboratory tests are conducted on water samples collected from a number of monitoring stations throughout the Elk Valley. These tests are part of Teck's routine water quality monitoring, which is conducted monthly (weekly during spring). The short-term laboratory tests use water fleas (a small 1 to 5 mm crustacean called *Daphnia magna*) and very young Rainbow Trout. The water sample passes the test if 50% or more of the organisms survive exposure (tests last 96 hours for trout and 48 hours for the water flea). Failing the test triggers follow-up investigations that may include re-testing the water sample or additional studies to determine the cause of the failure.

In 2018, 294 short-term tests with Rainbow Trout were conducted and all samples passed. A total of 305 water flea short-term tests were completed and four samples from Cataract Creek failed. Teck completed various follow-up studies and the results suggested that mineral precipitates (including calcite) were responsible for the failures.

Long-term laboratory tests are conducted every three months on water samples collected from the eight compliance points. These tests use algae, amphipods, water fleas, Fathead Minnows, and very young Rainbow Trout. Long-term tests range in duration from 72 hours (for algae) to 30 days (for Fathead Minnow and Rainbow Trout). About one third of the 115 long-term tests conducted with mine-influenced waters showed inhibited growth or reproduction in one or more of these organisms compared to the growth and reproduction of organisms held in reference (non mine-influenced) river water (Figure 24). Long-term test results help Teck and the EMC understand the health of the Elk River and its tributaries.

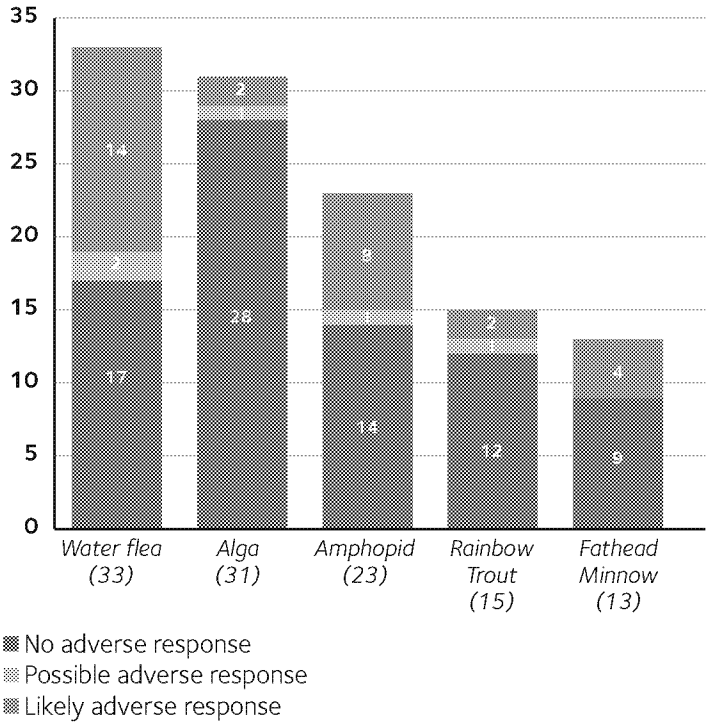

Figure 24. Number of long-term laboratory tests by species in 2018.

Nitrate and Sulphate Laboratory Tests

When the EVWQP was developed, the limits for nitrate and sulphate in the water were set based on the available science, as well as provincial and federal benchmarks. There was some uncertainty at the time whether these limits were low enough to protect the most sensitive aquatic organisms. Teck began conducting laboratory tests to investigate the tolerances of aquatic invertebrates, fish, and amphibians to nitrate and sulphate (at the same time) under conditions similar to what is found in the Elk Valley. The results from those tests have confirmed that the benchmarks used to develop the limits are in fact protective of sensitive aquatic invertebrates and fish, with a margin of safety potentially greater than prescribed in the EVWQP.

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The sensitivity of amphibians to nitrate and sulphate has not been well studied, and so their tolerances were unknown during the development of the EVWQP. Teck, therefore, started laboratory tests with frogs (Northern Leopard frogs) in 2016. Testing with frogs has been challenging. The tests require that the tadpoles be reared in the laboratory; a process that takes months. Studies in 2016 and 2017 produced unreliable results because of unexplainable mortalities in the control samples (lab water). The laboratory tests were repeated in 2018, this time with success. The 2018 results will be reported in 2019, but they generally support that the limits for nitrate and sulphate are low enough to protect amphibians as well as aquatic invertebrates and fish.

Amphibian Egg-Viability Laboratory Tests

Several species of amphibians live in the side channels of the Elk River and in its smaller tributaries. The sensitivities of amphibians to selenium has not been well studied. Teck conducted a preliminary study of selenium toxicity to Columbia Spotted Frog in 2012, but the EMC felt there remained a gap in understanding the risks of selenium exposure to the survival of larval Columbia Spotted Frog (and other amphibians) in the Elk Valley. In 2018, Teck collected fertilized egg masses of Columbia Spotted Frog from side-channels of the Elk River and reared them in the laboratory to evaluate the survival and deformity rates of eggs and tadpoles. The results showed no evidence of selenium effects on egg survival, or tadpole development, at egg selenium concentrations of up to 11 mg/kg dw. This work was repeated in 2019 to capture sites with a broader range of aqueous selenium concentrations as previous studies have observed concentrations upwards of 38 mg/kg dw.

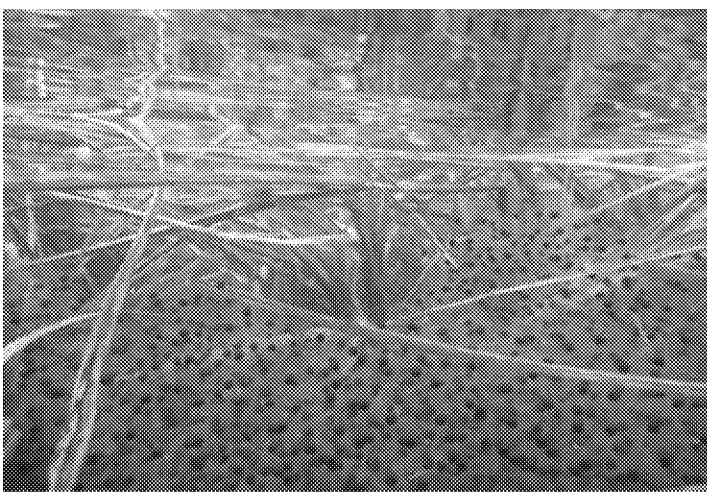

Figure 25. Columbia Spotted Frog egg mass within vegetation.

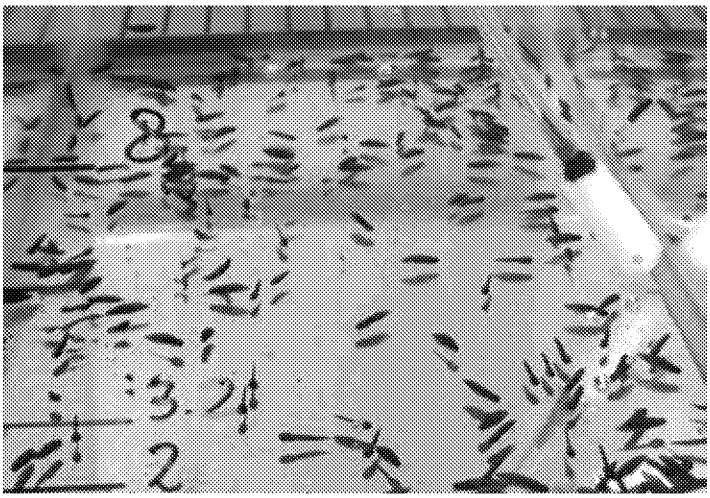

Figure 26. Columbia Spotted Frog tadpoles in the laboratory.

Fish Egg-Viability Laboratory Tests

The limits for selenium in the EVWQP were based on previous studies in the Elk Valley and elsewhere. To provide more confidence in the benchmark for concentrations of selenium in ovaries, egg-viability studies became a requirement in Permit 107517. Teck completed an egg-viability study in 2015 using eggs collected from Westslope Cutthroat Trout. That study measured the concentration of selenium in eggs and evaluated their survival and development in the laboratory. The EMC considered the results and determined they were sufficient to confirm the critical selenium level in Westslope Cutthroat Trout ovaries.

The EMC recommended the next egg-viability study should focus on Redside Shiners. Redside Shiners are small-bodied fish that are abundant in the Elk River watershed. Monitoring results from 2015 and 2016 show that this species accumulates greater amounts of selenium in its tissues compared to most other fish species and relative to tissue-based water quality guidelines in the Koocanusa Reservoir. The EMC recommended Redside Shiners for this study because little is known about the accumulation and toxicity of selenium in that species.

Teck designed and implemented an egg-viability study on Redside Shiners in 2018. Redside shiners were successfully maintained in the laboratory, but the fish would not spawn. The study continued in 2019, where Teck collected eggs of Redside Shiner, fertilized them in the field, and brought them back to the lab. Results showed no effect of selenium, at the tested concentrations, on survival, growth, or deformities for this species.

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Koocanusa Reservoir

The Koocanusa Reservoir straddles the border between Canada and the United States, and lies within the traditional territory of the Ktunaxa people. Three Canadian rivers supply most of the inflow to the reservoir: the Kootenay River (62%), the Elk River (26%), and the Bull River (11%).

Since 2014 Teck has conducted studies to understand the physical, chemical, and biological conditions in the Canadian portion of Koocanusa Reservoir. This program is designed to determine if conditions in the reservoir are changing and if those changes can be attributed to influences from the Elk River and upstream mining activities. Teck collects samples upstream and downstream of the Elk River confluence, and compares the results to identify potential mining-related effects. The results of this monitoring program are summarized in reports that Teck submitted to the Director:

- the 2014 to 2016 monitoring cycle[7] (submitted in June 2017)
- 2017 water quality conditions[8] (submitted in June 2018)
- year one of the 2018 to 2020 monitoring cycle[9] (submitted in June 2019)

Currently, Teck is continuing year two of the 2018 to 2020 monitoring cycle, collecting information on water (physical and chemical), sediment (physical and chemical), phytoplankton, zooplankton, benthic invertebrates, and fish.

Water Quality

Based on the results from 2014 to 2018, water quality in the Koocanusa Reservoir is generally good with minor exceptions. Concentrations of nitrate and selenium tended to be higher in areas downstream from where the Elk River flows into the reservoir (the confluence) compared to areas upstream of the confluence (when considering the annual average surface water quality). However, permit limits and BC water quality guidelines for nitrate, selenium, sulphate, and cadmium were met consistently at the order station in the Koocanusa Reservoir, except for selenium in April 2018.

In April and May 2018, the riverine condition of the reservoir prevented field samplers from accessing the usual permitted sampling location safely. The April samples were therefore collected along the eastern shoreline. In May 2018, water samples were collected from both the eastern and western shorelines. The differences in the concentration of water quality parameters (selenium, for example) between the shorelines suggested that the water at this sampling location was not fully mixed. Follow-up studies by Teck (from April to August 2018) have offered insight into how water from the Elk River and the Kootenay Rivers behave in the reservoir. When water levels in the reservoir are low and the reservoir is river-like, the Elk River does not substantially mix with water from the Kootenay River until 4 or 5 kilometres downstream of the permitted sample location. At higher water levels (June through August and beyond), substantial mixing did not occur until 15 kilometres downstream of the permitted sample location.

Figure 27. Riverine condition of the Koocanusa Reservoir in April and May 2018.

[7] Koocanusa Reservoir Monitoring Report, 2014 to 2016 (June 2017; updated June 2019)

[8] Permit 107517 2017 Summary Report of Monitoring Results in the Koocanusa Reservoir (June 2018)

[9] Koocanusa Reservoir Monitoring Program Annual Report, 2018 (June 2019)

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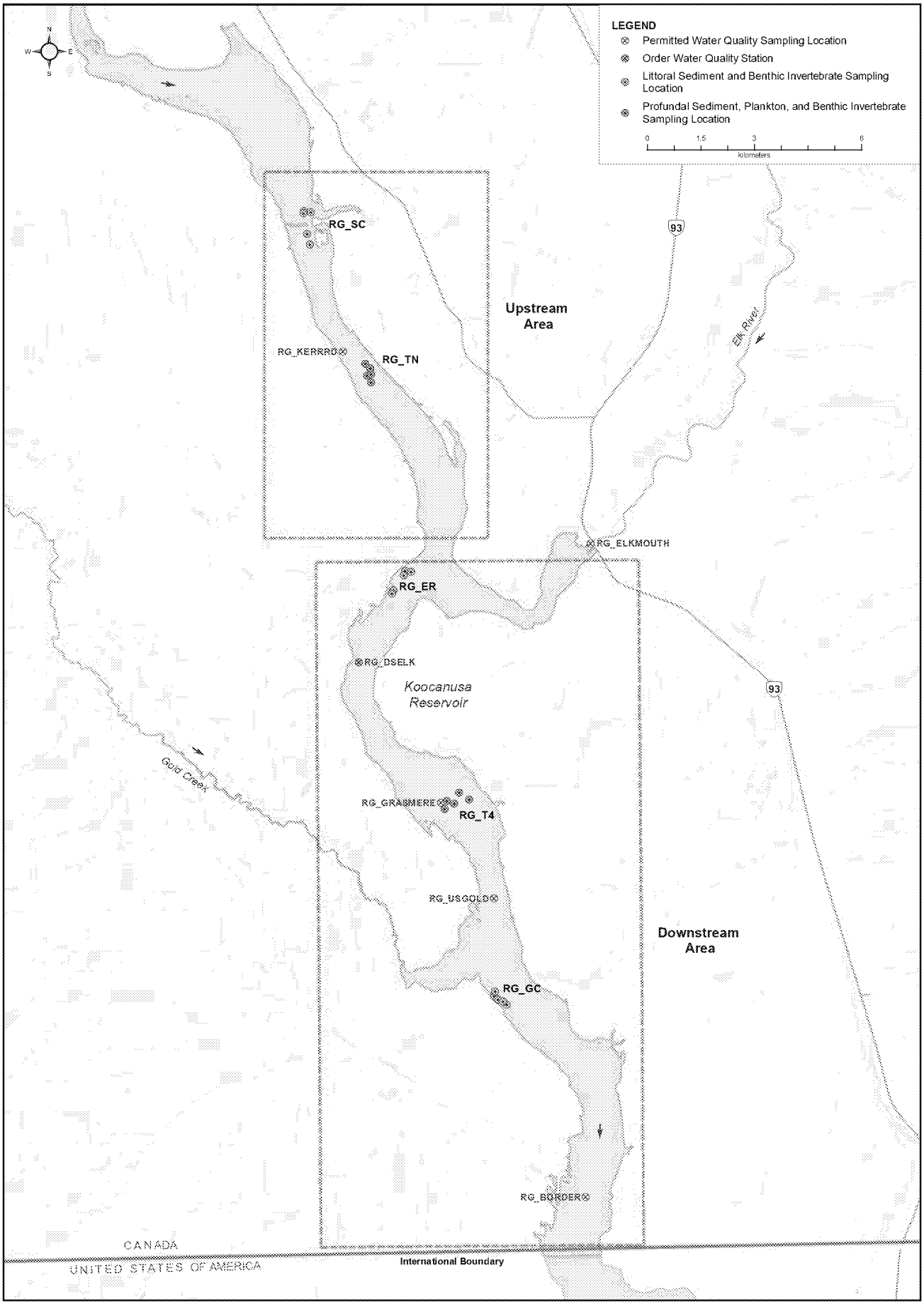

Figure 28. Teck's sampling locations in the Koocanusa Reservoir.

Sediment Quality

Sediment results from 2014 to 2018 showed that concentrations of most metals and polycyclic aromatic hydrocarbons[10] were higher in sediments collected downstream of the Elk River confluence, but these concentrations were all below the BC sediment severe-effects guidelines. Certain metals, including arsenic, nickel, iron, and manganese were above the BC sediment low-effects guidelines both upstream and downstream of the Elk River.

Aquatic Algae and Invertebrates

Samples of phytoplankton (tiny suspended algae) and zooplankton (tiny suspended invertebrates) were collected in Koocanusa Reservoir upstream and downstream of the Elk River confluence in 2015, 2016, and 2018. The numbers and kinds of organisms present (community structure) were evaluated, as well as the concentration of selenium in zooplankton. The results showed no significant differences between the upstream and downstream locations.

Clams, insect larvae, worms, seed shrimp, and mites were among the organisms found in reservoir sediments. These types of organisms are typical of reservoir habitat (deep and slow moving). There were minor differences in the kinds of organisms found in sediments downstream of the Elk River confluence compared to upstream, with natural variations in sediment texture likely to be the cause of those biological variations.

Fish

Teck collected samples of several different fish species in Koocanusa Reservoir from 2014 to 2018, including Peamouth Chub, Northern Pikeminnow, Largescale Sucker, Redside Shiner, and Yellow Perch. These samples provided important information on fish age, condition (weight in relation to length), liver size, gonad size, and growth. In addition to these fish health and population measurements, the concentration of selenium was measured in the muscle tissue, whole body tissues, and ovaries (Figure 30 and 31).

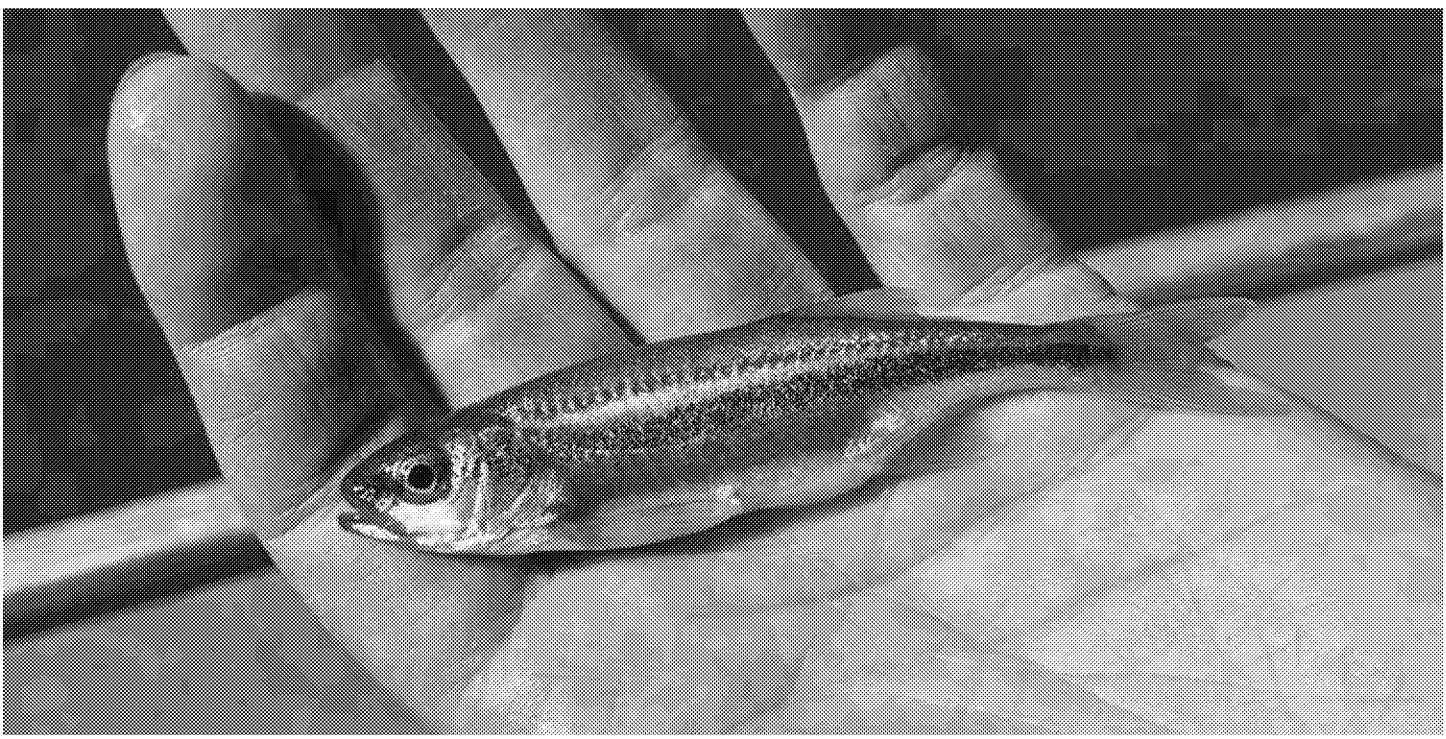

Figure 29. Redside Shiner

[10]Polycyclic aromatic hydrocarbons are organic compounds containing only carbon and hydrogen. They occur naturally and are released from burning fossil fuels, trash, tobacco, and wood.

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Teck conducted fish health surveys of Peamouth Chub and Redside Shiner in Koocanusa Reservoir that focused on fish survival (mean age), growth (body size-at-age), reproduction (relative gonad weight) and energy storage (relative liver weight and overall condition). The results from these surveys showed no consistent patterns among fish species, sexes, or sampling years that would indicate an influence from the Elk River (Table 1).

Selenium concentrations measured in fish tissues from Koocanusa Reservoir were compared to guidelines published by the USEPA[11] and the British Columbia Ministry of Environment. They were also compared to the benchmarks established in the EVWQP. Selenium guidelines for fish tissues are estimates above which there is a potential risk of reproductive impairment. Guidelines vary between agencies because each agency employs different methods for defining a protective threshold and the critical burden of selenium in fish tissue (causing reproductive effects) is an evolving field of study. It is agreed, however, that the concentration of selenium in ovaries is the most relevant measure for evaluating ecological effects because it is selenium in eggs that poses risk of reproductive effects in fish.

The average concentrations of selenium in the ovaries of fish collected from the reservoir were frequently above the BC guideline of 11 mg/kg dw, particularly in Peamouth Chub, Northern Pikeminnow, and Redside Shiner. For all species except Redside Shiner and Northern Pikeminnow, the average selenium concentrations in the ovaries were below both the EVWQP Level 1 benchmark (18 mg/kg dw) and the USEPA guideline (15.1 mg/kg dw). Redside Shiner samples were above the Level 1 benchmark at both downstream and upstream locations (above mine-influenced waters) in the three years it was sampled (2015, 2016, and 2018).

Table 1. Summary of statistical results for fish health endpoints for 2014, 2015, 2016, and 2018.

Sex	Response	Endpoint	Peamouth Chub				Redside Shiner	
			2014	2015	2016	2018	2016	2018
Female	Survival	Mean age	↑ O	O O	O ↓	O O	O O	O O
	Energy Use - Growth	Adjusted body weight-at-age	↑ O	O ↓	↓ ↓	O O	O O	O ↑
	Energy Use - Reproduction	Gonad weight-at-adjusted body weight	↓ O	O O	↑ ↑	O O	O O	O O
	Energy Storage	Condition (Adjusted body weight-at-fork length)	O ↓	O O	O O	↓ ↓	O O	O O
		Liver weight-at-adjusted body weight	O ↑	↓ ↓	↑ ↑	O ↑	↑ ↑	↑ O
Male	Survival	Mean age	↑ O	O O	O ↓	↓ O	O O	O O
	Energy Use - Growth	Adjusted body weight-at-age	O ↑	O O	O ↓	O O	O O	O O
	Energy Use - Reproduction	Gonad weight-at-adjusted body weight	O O	O –	↑ O	O O	O O	O O
	Energy Storage	Condition (Adjusted body weight-at-fork length)	↑ O	O O	O O	O O	↓ O	O O
		Liver weight-at-adjusted body weight	O ↑	O O	O O	↓ O	O ↑	O ↑

O no significant difference
↓ downstream fish significantly lower
↑ downstream fish significantly higher

Blue symbols: Fish collected in Koocanusa Reservoir near the Elk River relative to Sand Creek
Red symbols: Fish collected in Koocanusa Reservoir near Gold Creek relative to Sand Creek

[11] The acronym USEPA stands for the United States Environmental Protection Agency. The guidelines were published in 2016.

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Redside Shiners appear to have a greater body burden (greater accumulation) of selenium than most other species. The implications of these higher concentrations are currently unknown because no studies have been done to determine the toxicity of selenium on this species. Redside Shiners are highly abundant in the Elk Valley watershed, so the EMC has recommended a study to evaluate the effects of selenium on the early life stages of Redside Shiners (see page 42).

Individual fish, including Peamouth Chub, Northern Pikeminnow, Longnose Sucker, and Rainbow Trout collected downstream of the Elk River confluence had selenium concentrations above the Level 1 EVWQP benchmark for ovaries; however, only Northern Pikeminnow showed average selenium concentrations in their ovaries above the Level 1 benchmark. When a selenium guideline or benchmark is exceeded, it does not necessarily mean that there will be an effect to the organism. Fish species have a range of sensitivities to selenium in their ovaries, and critical levels have not been established for all the species that have been reported in the Koocanusa Reservoir. Ongoing and future studies will be evaluating the sensitivity of species that exhibit elevated selenium in their tissues to better understand whether effects are expected.

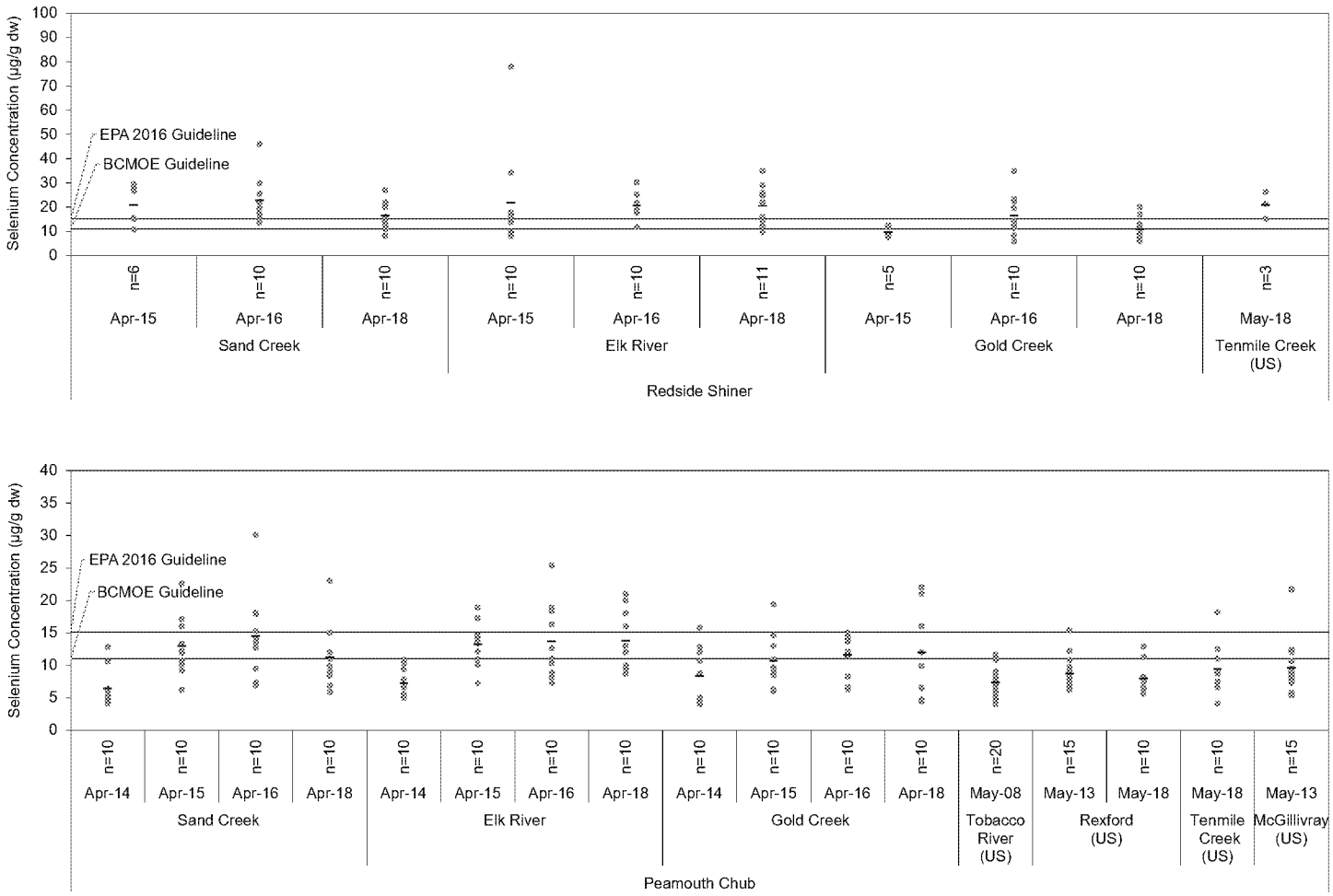

Figure 30. Concentrations of selenium (mg/kg dw) in the gonads and ovaries of Redside Shiner and Peamouth Chub in the Koocanusa Reservoir from 2008 to 2018.

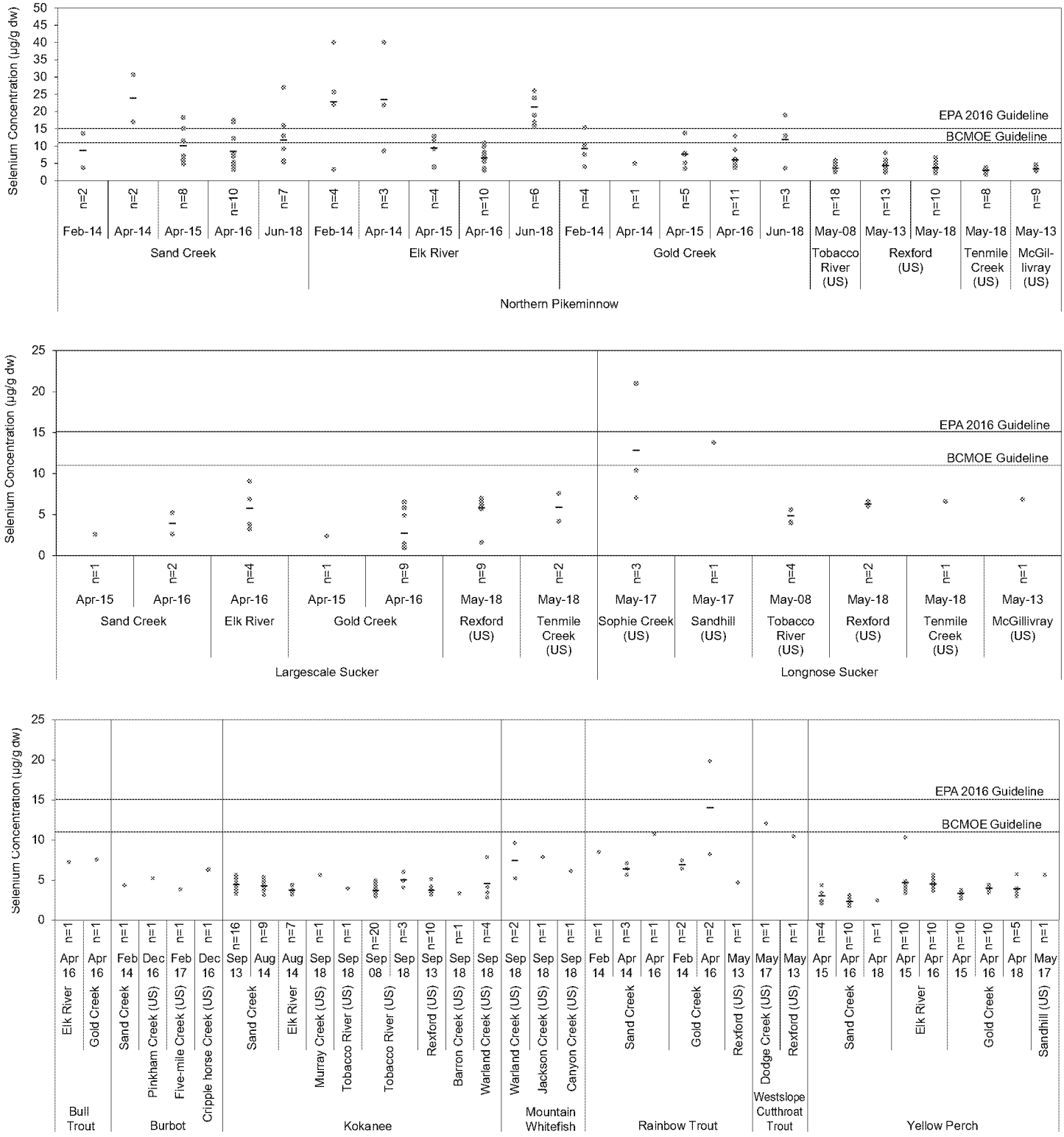

Figure 31. Concentrations of selenium (mg/kg dw) in the gonads and ovaries of various fish species in the Koocanusa Reservoir from 2008 to 2018.

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Other Programs

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Human Health

Teck is required to conduct a human health risk assessment for the Elk Valley. A human health risk assessment determines the potential risks to human health posed by the presence of certain substances within a defined area. It considers the toxicity of the substances, how much of the substances humans are exposed to, and how often. A human health risk assessment is not a monitoring program, but rather a snapshot in time that relies on the most recent monitoring results from other programs.

Teck submitted a Human Health Risk Assessment (HHRA) report to the EMC and the Director in March 2016. After reviewing that report, two EMC member organizations (IHA and KNC) felt the potential health risks to Ktunaxa citizens—based on their preferred consumption rates of wild foods—were not addressed. To address these concerns, Teck evaluated the risks associated with consuming wild foods at the preferred rates defined in the Ktunaxa First Nation Diet Study (Firelight 2015). Teck described the results of their evaluations in a technical memo and submitted it to the EMC and the Director in September 2016. Following the review of that technical memo, the EMC acknowledged that there were information gaps in what was known about current and preferred consumption rates. In addition, IHA and KNC felt that two separate documents would be a source of confusion and misunderstanding among community members, decision-makers, and other readers, and felt the 2016 HHRA should be reissued. KNC also had outstanding concerns with the portrayal of the preferred consumption rates in the follow up evaluation.

IHA and the KNC, with support from the First Nation Health Authority, reached out to the Director and the Ministry of Health to express their concerns and to resolve the stalemate over the 2016 HHRA. The Director has formally acknowledged that Teck submitted the HHRA report by the permit deadline, but the report has not yet been approved or rejected. The Director is expecting that Teck work with KNC and IHA to resolve the information gaps and submit an updated HHRA that includes a complete analysis of both current and preferred consumption rates in one report due later in 2020.

The KNC is working on an updated preferred consumption rate study which will inform the 2020 HHRA. And Teck, KNC, and IHA are working together to define the objectives and scope for an updated human health risk assessment, meeting every month for targeted discussions to ensure progress on this important file. Teck and the KNC are continuing with the wild foods sampling program to provide additional information for the assessment.

What are wild foods and what is the Wild Foods Sampling Program?

Wild foods are plants or animals harvested from the land and water that humans eat or use for teas and medicine. Some examples are rose hips, huckleberries, fish, elk, and deer.

Teck accepts donations of small samples (about ½ cup) of wild foods harvested from the Elk Valley. Teck sends the samples to a laboratory to measure the concentration of mine-related substances. The results from the wild foods sampling program are used in all human health risk assessments in the Elk Valley. If you are interested in learning more about the program and possibly donating a sample or two, you can email samples.teckcoal@teck.com.

Is the water safe to drink?

The Interior Health Authority recommends that people do not drink surface water (from rivers, streams, or lakes) anywhere in the province. Surface water can contain microbiological contaminants (bacteria, viruses, and parasites) and industry-related substances. In the Elk Valley, industry-related substances are largely mine-related. Untreated surface water should be boiled to address microbiological contaminants, but this will not address risks associated with mine-related substances.

In the Elk Valley, the surface water at many locations has selenium concentrations above the BC drinking water guideline of 10 µg/L (see map on page 51). Some of these locations see these levels only during winter months, but some locations (such as tributaries close to mine operations) see these levels year round. Short-term exposure (skin contact or ingestion) from time to time is not a health risk; however, long-term frequent exposure increases the health risk. See page 20.

Drinking water systems in the Elk Valley depend on groundwater wells, not surface water. The selenium levels in tested drinking water wells are generally below 10 µg/L, with the exception of four private wells. We encourage private well owners in the Elk Valley to contact Teck to have their water tested.

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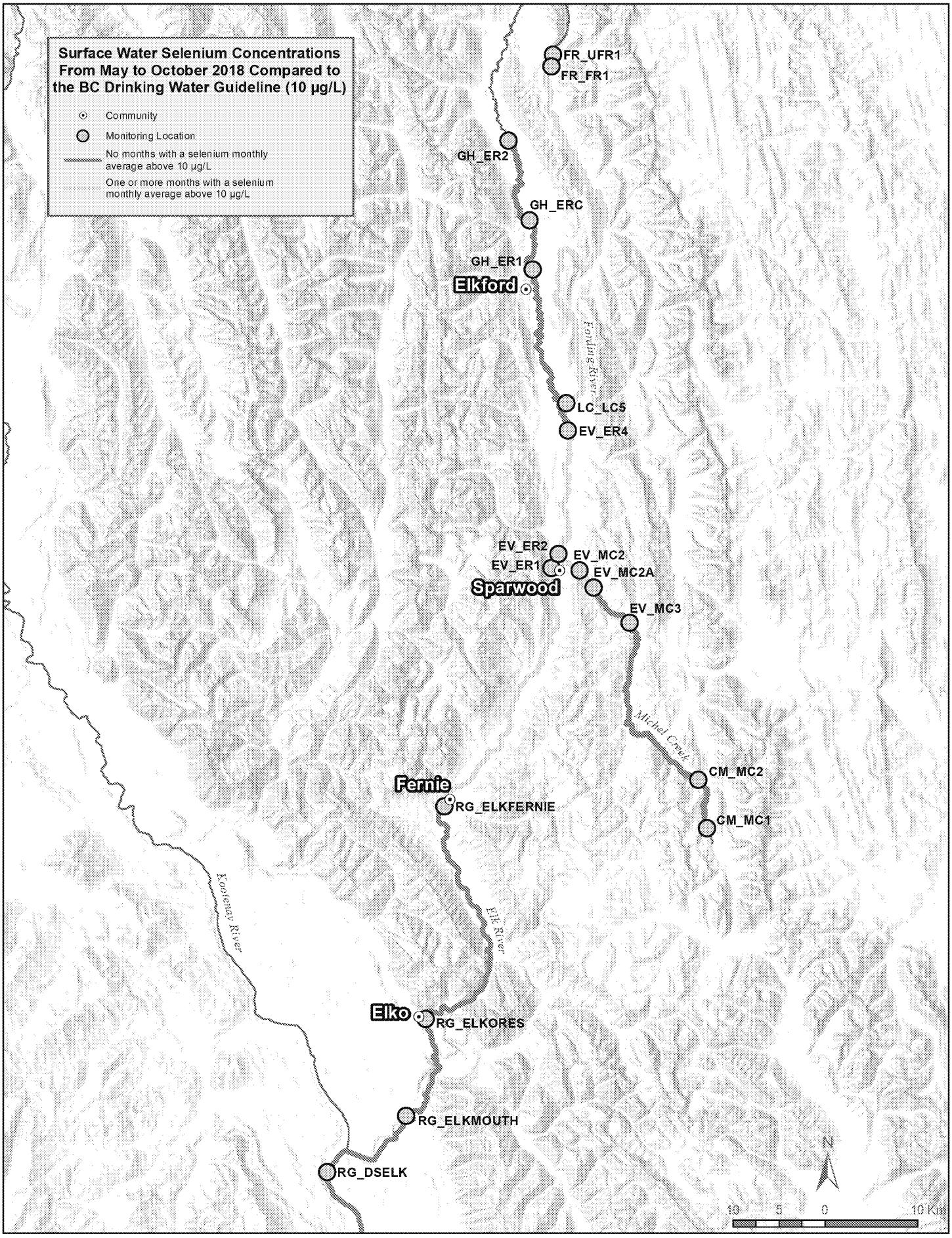
Surface Water Selenium Concentrations From May to October 2018 Compared to the BC Drinking Water Guideline (10 µg/L)
Community
Monitoring Location
No months with a selenium monthly average above 10 µg/L
One or more months with a selenium monthly average above 10 µg/L
FR_UFR1
FR_FR1
GH_ER2
GH_ERC
GH_ER1
Elkford
Fording River
LC_LC5
EV_ER4
EV_ER2
EV_ER1
EV_MC2
EV_MC2A
Sparwood
EV_MC3
Michel Creek
CM_MC2
CM_MC1
Fernie
RG_ELKFERNIE
Kootenay River
Elk River
Elko
RG_ELKORES
RG_ELKMOUTH
RG_DSELK
N
10 5 0 10 Km

Tributary Management

Tributaries are smaller streams that flow into a larger stream or river (which are sometimes referred to as a mainstem) or a lake. Tributaries provide vital habitat for a variety of aquatic life and are important for the overall health of an aquatic ecosystem.

Mining activities have the potential to affect the quality of water and habitat in tributaries, and in some cases the removal of tributary habitat was permitted to allow for mining of coal resources. Permit 107517 requires Teck to complete a tributary evaluation and to develop a tributary management plan with advice from the EMC. Permit 107517 states:

> *The Tributary Management Plan is intended to incorporate protection and rehabilitation goals for tributaries that will support achieving the area-base objectives of the EVWQP. In development of the Tributary Management Plan, those tributaries that are not impacted by mining activities, that provide relatively high habitat value, and/or support ongoing habitat use by fish and sensitive aquatic-dependent wildlife (i.e., directly or indirectly through food production) shall be identified as the highest priority tributaries for permanent protection. Those tributaries that have been impacted by mining, provide or have the potential to provide relatively high habitat values, and/or support or could support habitat use by fish and sensitive aquatic dependent wildlife shall be identified as the highest priority tributaries for restoration or rehabilitation.*

The tributary management plan must be updated each year. Teck has been developing the Tributary Management Plan with the EMC since 2016, and submitted the first plan in 2017. This plan was accepted by the Director in February 2018 with conditions for the 2018 plan. EMC discussion and advice on the 2018 plan reflects differing perspectives on this plan.

What is an aquatic ecosystem?

An aquatic ecosystem is all living things that depend on each other and their environment for food and shelter. This includes bacteria, fungi, insects, snails, and tiny free-floating plants and animals called plankton. There are also large plants—like cattails and reeds—plus fish, amphibians, reptiles, and birds.

This plan will guide Teck's environmental management of tributaries and Teck will refer to this plan during mine planning. The overall goal of the Tributary Management Plan is to

> *Protect and rehabilitate tributaries of the Elk River watershed on a priority and feasibility basis to benefit fish, aquatic-dependent wildlife, and vegetation, recognizing biological, social, and economic values, and Ktunaxa worldview.*

All the tributaries upstream of Sparwood that flow into the Fording River, Michel Creek, and the Elk River—and that are currently mine-influenced[12] or could be influenced by Teck's future development plans—are included in the management plan[13]. The mainstem of the Fording River, Michel Creek, and the Elk River are not considered to be tributaries and are managed according to the EVWQP and Permit 107517. Tributaries that have been permanently removed or severely altered by mining activities are also not included, consistent with Permit 107517 which states these are out of scope.

In developing the Tributary Management Plan, Teck and the EMC undertook two important activities: tributary evaluation and tributary prioritization.

[12] Mine-influenced means that the mine footprint extends into a tributary's catchment, so the tributary receives water that has been changed from being in contact with mine works.

[13] The plan also includes two tributaries that flow from the area of Coal Mountain Phase 2 into the Elk River near Hosmer.

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Tributary Evaluation

Teck assessed the ecological value of the tributaries of the Elk River and the Fording River and identified those tributaries that play a significant role in supporting the Elk Valley watershed as a whole. Teck worked with the EMC and the Elk Valley Fish and Fish Habitat Committee throughout this activity to make sure the evaluation results were supported by local knowledge. Teck submitted the results of this evaluation to the Director in June 2016.[14]

Tributary Prioritization

Once the tributaries were evaluated, the next step for Teck was to determine which tributaries were a priority for protection, rehabilitation, or both. Teck developed a tool (with EMC advice) which generated prioritized lists of tributaries. The EMC participated in an exercise to consider the biological values of all the tributaries and brought forward considerations for interpreting the lists. Teck considered all the input from the tool and the EMC when it determined the final prioritized list. The EMC does not have consensus on all tributary priorities.

Teck must update its Tributary Management Plan each year to include changes to its current and future mine development plans. The EMC reviews and discusses the draft versions of each annual update and all the supporting materials and information. Teck considers all the input the EMC provides before submitting the final version to the Director. The Director is currently reviewing and considering the 2018 Tributary Management Plan, which was submitted in February 2019. The EMC continues to discuss implementation and future refinements of the plan.

[14] Data Report for the Tributary Evaluation Program

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Glossary and Appendices

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Glossary

active water treatment
a method of removing substances from water that requires regular human intervention and management. For example, the active water treatment facility at Line Creek Operations uses a system of tanks that use bacteria and other micro-organisms to remove mine-related substances from the water.

acute toxicity
the adverse effects of a substance on an organism that result from either a single exposure or from multiple exposures in a short period of time.

adaptive management
a systematic, rigorous approach to environmental management that focuses on learning about important uncertainties, while at the same time implementing management actions based on the current understanding.

aquatic organisms/aquatic life
animals (invertebrates, amphibians, fish, birds, etc.) that live in or depend on an aquatic environment.

area-based management plan
an environmental management plan for a designated area under the Environmental Management Act.

baseline
current or existing conditions that serve as a reference point for comparing future conditions.

benchmark
a standard or point of reference against which things may be compared or evaluated. See also effect benchmark and Level 1 benchmark.

benthic invertebrates
small organisms that lack backbones and live in or on the bottom of sediments of rivers, streams, and lakes; these include the larvae of aquatic insects, as well as clams, snails, mussels, crayfish, and various other kinds of aquatic worms.

bioaccumulation
the buildup of substances, both toxic and benign, within the body tissues of an organism.

calcite
a mineral made up of calcium, carbon, and oxygen.

calcite index
a numeric expression of the extent and degree of calcite formation; typically given as a range from 0 to 3.

chronic toxicity
the adverse effects of a substance on an organism that result from long-term exposure.

compliance point
a water monitoring station that is immediately downstream from one Teck's mine operations in the Elk Valley.

constituent
an element, substance, or ionic compound

control sample
a sample containing water that has not been modified or impacted by mining, that is subjected to the same analyses as the mine-water being tested; this helps to confirm the quality and reliability of the results. See also lab water.

crustacean
a large, diverse group of invertebrates with an external skeleton.

daily maximum limit
the maximum allowable concentration of a substance in a 24-hour period.

Director
the governmental office within the British Columbia Ministry of Environment and Climate Change that is responsible for issuing permits under the Environmental Management Act and for determining compliance with permit requirements.

discharge, v
flowing from one source into another.

effect benchmark
the concentration of a substance shown to produce a specific level of effect on an organism.

effluent
outflow or waste from human activities that is introduced into water or onto land.

Elk River watershed
the area that includes the Elk River and all of its tributaries.

Environmental Management Act
a British Columbia legislation that regulates release of effluent to water, land, and air.

exposed site/area/stream
sites, areas, or streams that are downstream of mining activities.

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groundwater
water that flows beneath the water table, in soils and geologic formations.

hardness, hard water
water with a high content of calcium and magnesium or other dissolved metals.

human health risk assessment
an assessment to determine the potential risks to human health posed by the presence of contaminants within a defined area.

lab water
distilled or city water sometimes used in control samples in laboratory tests.

Level 1 benchmark
the concentration above which there is a potential for a 10% effect on the growth or reproduction of an organism.

local aquatic effects monitoring program
programs designed to answer specific questions about aquatic effects that arise because of the unique circumstances of a particular mine operation.

larval stage, larvae
the newly hatched, juvenile form of an animal before metamorphosis into an adult.

monthly average
the average of all samples collected in a calendar month at a sample location.

order station
a location specified by Ministerial Order No. 113 to monitor water quality.

periphyton
freshwater organisms such as algae and bacteria that attach to rocks, plants, suspended particles, and other objects in the water.

phytoplankton
microscopic algae that live in the water column and are food for zooplankton and fish.

pit dewatering
the movement of water from pits to support mine operations

reach
a section of a stream that is typically 100 metres long or more.

reference (stream, area, tributary)
a watercourse that has not been affected by mining activity; typically located upstream of mine operations.

regional aquatic effects monitoring program
a long-term monitoring program to assess potential regional-scale effects in the aquatic environment downstream of mining operations within the Elk River watershed.

site performance objective
an authorized limit or standard set by the Director for specific location.

tributary
a river, stream, or creek flowing into a larger river or lake.

water quality guideline
the recommended limit for the concentration of a substance in the water to protect ecological or human health; may be federal or provincial.

water quality limit
an authorized limit for the concentration of a substance in the water set by the Director for specific location.

wild foods
food that is harvested through hunting, gathering, and fishing.

zooplankton
tiny invertebrates that live in the water column and are food for many fish species.

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Appendix A - The Ktunaxa Nation and the Elk Valley

The Ktunaxa Nation is made up of all Ktunaxa citizens residing both within and outside of **Ktunaxa ʔamakʔis**, including the member communities and their citizens. The northern portion of **Ktunaxa ʔamakʔis** has historically been claimed by Canada, while the southern half is claimed by the United States. In Canada, the member communities of the Ktunaxa Nation include, **ʔakink'umɬasnuqɬiʔit** (Tobacco Plains Band), **ʔaq̓am** (formerly known as St. Mary's Band), **yaqan nuʔkiy** (Lower Kootenay Band), and **ʔakisq'nuk** (Columbia Lake Band). The Ktunaxa Nation maintains unceded Aboriginal title in much of what is now considered the East and West Kootenays. Ktunaxa communities south of the Canada-USA border are located in what is now Idaho and Montana. The Elk Valley, which is wholly within the unceded and unsurrendered territory of the Ktunaxa has been occupied continuously by the Ktunaxa Nation since time immemorial, and is maintained as Aboriginal title by the Ktunaxa Nation. The British Columbia (BC) portion of the traditional territory is subject to ongoing treaty negotiations with the Province of BC and the Government of Canada.

The Elk Valley was traditionally used and occupied by the Ktunaxa Nation. Important Ktunaxa settlements were maintained in the Elk Valley well into the 20th century, and Ktunaxa citizens continue to reside throughout the lower Elk Valley, including in Sparwood, Fernie, and elsewhere. Ktunaxa oral histories, supported by historic archival and ethnographic data, suggest that Ktunaxa presence in the Elk Valley has long been centred on an important habitation area named **k̓ aqawakanmituk**, a Ktunaxa settlement at the confluence of Michel Creek and the Elk River near present-day Sparwood. This is a very important cultural area in the Elk Valley. It was occupied annually, and likely for a long period of time up to the late 1800's, by the Michel Prairie people, also referred to as the Fernie Band, or **k̓ aqawakanmituknik̓**. This was a historic Ktunaxa community with close ties to the current Ktunaxa community of Tobacco Plains whose annual round included hunting bison on the eastern slopes of the Rocky Mountains. As described further below, many Michel Prairie people died as a result of early smallpox epidemics, likely in the late 1700s.The settlement of **k̓ aqawakanmituk** at Michel Prairie included important tobacco cultivation areas, as well as habitation areas, processing areas, and other features including trails that connected the valley to mountain passes to the east. While there are no reserve lands in the Elk Valley, the Ktunaxa understand that reserve areas were promised in the area of Michel Flats and present day Sparwood, but were never formally allotted.

The Elk Valley itself falls within the Ktunaxa traditional land district of **qukinʔamakʔis**. **Qukin ʔamakʔis** is translated as Raven's Territory, Raven's Land or the Land of Raven. It is also sometimes used as a synonym for the Elk Valley because the valley and its surrounding mountains make up the majority of the lands associated with Raven. Today, the Elk Valley is known to Ktunaxa peoples not only for the richness of its fish and game but also for the presence of coal and extensive coal mining, and the associated restrictions on access to mining lands, many of which are private. For the Ktunaxa Nation, the history of coal mining in the Elk Valley, including recent history, has been a story of exclusion with more than a century of efforts by non-Ktunaxa individuals and companies to extract **qukin nuʔkiy** (Raven's Rock, or Coal) from **qukinʔamakʔis** (Raven's Land). Available information (archival and ethnographic), as well as oral histories and archaeology, supports an understanding that the Elk Valley in general, and specifically the upper Elk River, including areas around Michel Creek, Line Creek, Grave Creek, Round Prairie, and the Fording River, has been continuously used and occupied by Ktunaxa peoples, and specifically Upper Ktunaxa peoples, for hundreds of years prior to 1846.

Water is fundamental to the Ktunaxa creation story, and is understood by Ktunaxa knowledge holders to be the basis for all living things within **Ktunaxa ʔamakʔis**. Rivers, streams, lakes, and riparian areas provide essential habitat for the fish, and many of the animals and plants that Ktunaxa harvesters rely on, and responsible stewardship of water is a critical component of Ktunaxa responsibility. The Ktunaxa principle **ofʔa'kxam̓ is q̓** apiqapsin is translated to mean a responsibility for stewardship of all living things. Within the borders claimed by Canada and British Columbia, the **ʔamakʔis** of the Ktunaxa Nation covers approximately 70,000 km2 (27,000 square miles) of mountains, valleys, rivers and lakes in the Kootenay region. The region's landscape is alive with Ktunaxa culture and history. The Ktunaxa creation story relates the origins of the Ktunaxa people and describes the events and relationships that helped shape—and continue to shape—**Ktunaxa ʔamakʔis**. The geography of the Elk Valley is formed in the final events of the story, when the animal chief and creation hero, **Naɬmuqƛin**, collapses, forming the Rocky Mountains with his body.

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Ktunaxa Law

Ktunaxa law (**ʔaknumuɢtitit**) and oral history (**ʔaqaɬq'anuxwatiɬ**) are both sacred and legal in nature. Ktunaxa land use rights are based on a sacred covenant with the Creator, whereby, in exchange for the land providing the Ktunaxa with the necessities of life, the Ktunaxa are responsible as stewards of the lands and resources in **Ktunaxa ʔamakʔis**. The Ktunaxa have terms that address the natural world and how people are a part of it. **ʔakuk'pukam** speaks to anything that gets life from the earth through roots. **ʔakuk'pukamnam** adds the human dimension, whereby the earth's life is translated into human life. That is, the Ktunaxa have roots that tie them to **Ktunaxa ʔamakʔis**, and they are of the earth. In other words, they believe that what they do to the earth, they do to themselves and to future generations. The Ktunaxa phrase that captures interconnectedness and the stewardship concepts applicable to land management is **YaqatHankatititkinaʔamak**. This phrase translates to "our people care for the land, the land cares for our people."

More information on the Ktunaxa laws and principles can be found in Section C for the Baldy Ridge Expansion project found on the Environmental Assessment Office website (https://projects.eao.gov.bc.ca/p/baldy-ridge-extension/docs).

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Ktunaxa Creation Story

In ancestral times referred to by the Ktunaxa as the animal world, there were references made many times by the Creator to when there will be ʔaqɬmakniḱ (people).

At that time, there was some disturbance caused by a huge sea monster known as Yawuʔniḱ, who killed many of the animals. A council was called by the Chief animal, Naɬmuqɛ̓in. Naɬmuqɛ̓in was huge. He was so tall that he had to crawl on his hands and knees, for if he stood up his head would hit the ceiling of the sky.

It was decided that Yawuʔniḱ had to be destroyed. A war party was formed. Yawuʔniḱ plied the Kootenay and Columbia River System including Columbia Lake and Arrow Lakes.

Yawuʔniḱ was sighted in the Columbia Lake near Yaqa·n Nuʔkiy and the chase was on. At that time, the Kootenay River and the Columbia Lake were joined. As the chase proceeded, Naɬmuqɛ̓in gave names to many locations along the Kootenay River, Kootenay Lake, Arrow Lakes and the Columbia River.

Yawuʔniḱ was pursued down the Kootenay River past the Wasa sloughs, now called Wasa, BC. Skinkuɛ̓ got into trouble here when he fell into the river and had to be rescued by Wasa, (horse-tail).

The chase went by where the St. Maryʼs River empties into the Kootenay River. ʔaq̓am, where the St. Maryʼs Reserve is now located, then on down river to Kanḱak (spring) where Mayuk (weasel) joined the war party. There were animals on both sides of the river as the chase continued, and among the party was a parasite, ʔa·kukɬakuwum, who had to be carried on the backs of other animals. His name was Ƛ̓umtus and he was mean and bossy. The other animals grew tired of his nagging and dumped him into the river at a place now known as Yaqakiɬ wat̓mitquɬiɬki Ƛ̓umtus.

Leaving the land of the Eagle, ʔa·knuqɬuɬam̓ʔamaḱis and into the land of the woodtick, Ƛam̓na ʔAmakis, past Wasaʔki (Waldo) then on past the now 49th Parrallel and then past Kaxax (Turtle), now underwater, near Rexford, Montana. The chase went on by ʔa·kiʔyi (jennings) and on by ʔaqswaq (libby) then into Skinkuɛ̓ ʔAmakis (the land of Coyote), past ʔaq̓anqmi (Bonners Ferry, Idaho) then northerly past the now international boundary into ʔaɛ̓pu ʔamakis, the land of the Wolverine, past Yaqa·n Nuʔkiy (Creston, BC) then up the Kootenay Lake past ʔaq̓asqnuk, (Kuskannok, BC). The chase went on by ʔAkuqɬi (Akokli Creek), past Ksanka Creek. The Yawuʔniḱ chose to follow the Kootenay River past ʔaqyamɬup (Nelson, BC). The chase was now in Miɛ̓qaqas ʔamakis (the land of Chickadee).

At Kiḱsiɬuk, (Castlegar, BC) Yawuʔniḱ went north into the Arrow Lakes, past ʔakinḱaʔnuk (Arrow Rock) where arrows were shot into a crevice in the rock. If the arrow was true, the journey continued, if the mark was missed, beware, danger ahead. The arrow was true and the journey continued past Ƛaɬnuʔniḱ (Nakusp) then up past Ktunwakanmituk Miɛ̓qaqas (Revelstoke, BC) where the Columbia River flows into the Arrow Lakes, then up and around The Big Bend then down past ʔaknuqɬuk (Golden, BC) past Yaknusuʔki (Briscoe, BC) then on past Yakyuɛ̓ki. The chase carries on through Kwataq̓nuk (Athalmere) then past Kananuk (Windermere, BC) past ʔakisk̓q̓nuk (Windermere Lakes), then back into the Columbia Lake, Yaqa·n Nukiy, (Canal Flats, BC). This completed the cycle of the chase.

Yawuʔniḱ would once again escape into the Kootenay River and the chase would go on. The chase would go on and on. Every time the war party thought they had Yawuʔniḱ cornered, Yawuʔniḱ would escape again.

One day sitting on the river bank observing the chase was a wise old one named Kiḱum. Kiḱum told Naɬmuqɛ̓in, You are wasting your time and energy chasing the monster. Why not use your size and strength and with one sweep of your arm, block the river from flowing into the lake and the next time the monster enters the lake you will have him trapped. Naɬmuqɛ̓in took the advice of Kiḱum and did as he was told. The next time Yawuniḱ entered the lake, he was trapped.

Having successfully corralled Yawuʔniḱ, a decision had to be made as to whom the honor of killing Yawuʔniḱ would be bestowed upon. The honor was awarded to Yamakpaɬ (Red-headed Woodpecker).

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When Yawuʔnik̓ was killed, he was taken ashore and butchered and distributed among the animals. There remained only the innards and bones. The ribs were scattered throughout the region and now form the Hoo Doos seen throughout the area.

Naɬlmuqɛin then took the white balloon-like organ, known as the swim bladder, and crumbled it into small pieces and scattered it in all directions saying, 'These will be the white race of people'. He then took the black ingredient from the inner side of the backbone, the kidney, and broke it into small pieces and scattered them in all directions declaring,'These will be the black race'. He then took the orange roe and threw the pieces in all directions saying,'These will be the yellow race of people'.

Naɬmuqɛin looked at his bloody hands and reached down for some grass to wipe his hands. He then let the blood fall to the ground saying, 'This will be the red people, they will remain here forever'.

Naɬmuqɛin, in all the excitement, rose to his feet and stood upright hitting his head on the ceiling of the sky. He knocked himself dead. His feet went northward and is today know as Ya·ɬiki, in the Yellowhead Pass vicinity. His head is near Yellowstone Park in the State of Montana. His body forms the Rocky Mountains.

The people were now keepers of the land. The spirit animals ascended above and are the guiding spirits of the people.

Ktunaxa Nation website: Ktunaxa.org

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Appendix B - New Technical Reports Available Online

A number of Teck's technical reports are now available online. Most of these reports are those that have been reviewed by the Environmental Monitoring Committee and submitted to the Director under Permit 107517. Some reports are provided as additional information, but are not formally reviewed by the EMC. The following reports will be added in 2019.

- Surface Water Quality Monitoring 2018 Report
- Chronic Toxicity Testing Program 2018 Report
- Fording River Operations Local Aquatic Effects Monitoring Program 2018 Report
- Greenhills Operations Local Aquatic Effects Monitoring Program 2018 Report
- Line Creek Operations Local Aquatic Effects Monitoring Program 2018 Report
- Calcite Monitoring Program 2018 Report
- Calcite Effects on Fish Spawning and Incubation 2018 Report
- Regional Groundwater Monitoring Program 2018 Report
- Koocanusa Reservoir Monitoring 2018 Report

You can find the technical reports at: https://www.teck.com/responsibility/sustainability-topics/water/water-quality-in-the-elk-valley/research-and-monitoring-reports/

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Appendix C - Feedback Form

Please contact the independent facilitator for the Environmental Monitoring Committee if you have questions about this report, the Committee, or the science-based advice it provides.

Contact Information:
Environmental Monitoring Committee
Lynne Betts, Independent Facilitator
emcpermit107517@gmail.com

☐ Notify me about the EMC's annual public meetings and reports.

I would like to request the EMC's advice or input, plus feedback from Teck on the following:

☐ Surface Water Quality

☐ Groundwater Quality

☐ Effects on Aquatic Life

☐ Koocanusa Reservoir

☐ Tributary Management

☐ Adaptive Management

☐ Human Health

Name: _____

Affiliation (if any): _____

Email: _____ Phone: _____

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